Alternative Evaluation Report

Replacement of Upper Batavia Dam
Kane County, Illinois

Prepared for:

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

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INTRODUCTION

Summary

This report summarizes the results of the alternative evaluation process for the replacement of the Upper Batavia Dam. The dam was originally constructed in the 1800s to generate hydro mechanical power for a saw and grist mill. There is currently a breech near the east abutment. The existing purpose of the dam is to maintain the upstream pool for aesthetic concerns. All of the alternatives presented in this report look at maintaining an impoundment for the City of Batavia, while providing for recreational boat passage, fish passage and improved habitat, and environmental restoration. Two of the alternatives include lowering the elevation of the upstream pool in the river channel and river restoration in conjunction with the construction of a 12 foot high earthen dam to impound Depot Pond.

Location

The Upper Batavia Dam is located on the Fox River in Kane County, Illinois. Figure 1 is a vicinity map showing the general location of the study reach. The Fox River originates in Wisconsin, north of Waukesha. There are 15 dams located along the Fox River in Illinois, as show in Figure 2. The Upper Batavia Dam is on river mile 56.298 of the Fox River and within the City of Batavia.

Figure 1 - Vicinity Map

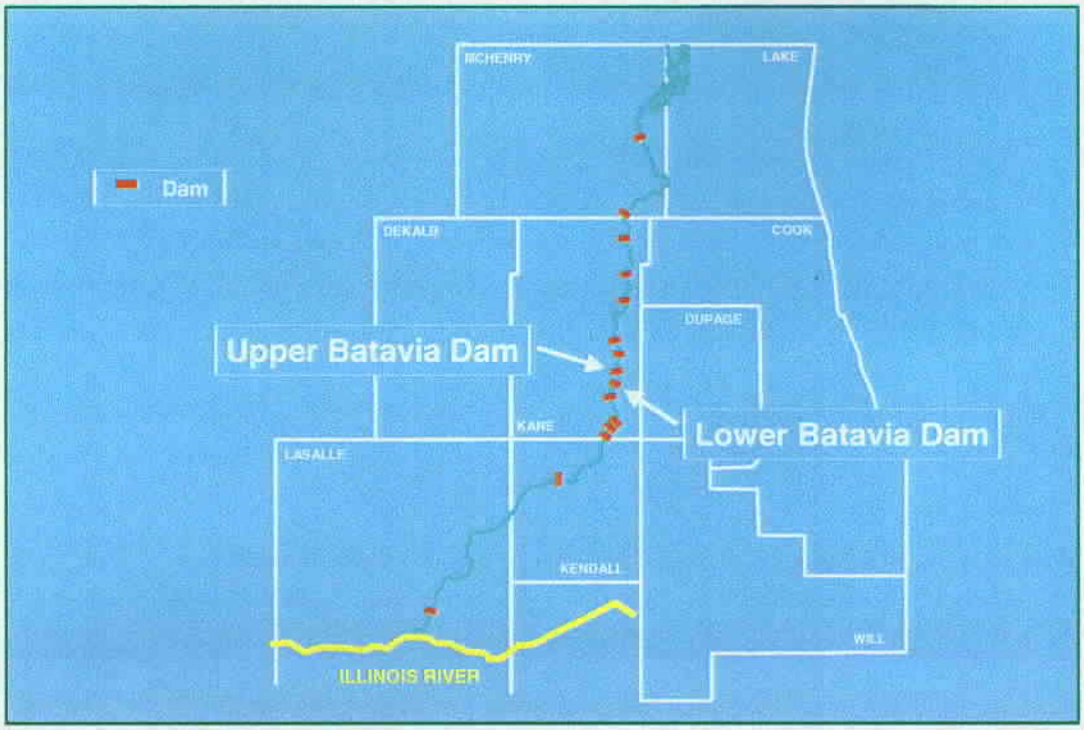


Figure 2 -Location of Dams Along Fox River (Ref. 1)

Project History

The original dam was constructed as a wood and rock crib dam in the late 1830s. It was replaced with a concrete modified ogee shape low-head dam in the early 1900s. Figure 3 shows a historical aerial photograph from 1946. The west abutment of the dam was breached in the mid 1970s. At that time, repairs were attempted but were not successful. Currently, during periods of low flow, all of the flow is conveyed through the breach and the upstream pool elevation is not maintained at the elevation of the dam's crest.

Figures 3 and 4 are aerial photographs, which compare the similarities and differences between site conditions from 1946 and 1998. In general, there does not appear to be significant changes within this reach over the past 60 years, which indicates a stable river reach.

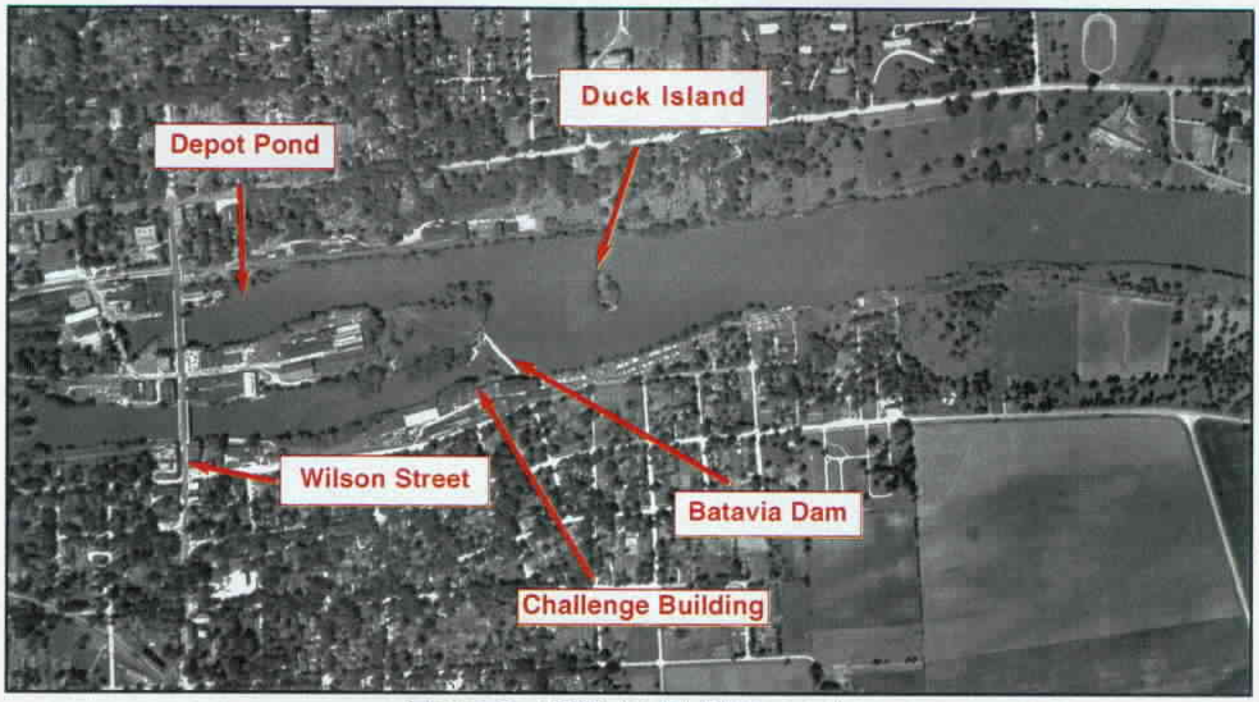


Figure 3 - 1946 Aerial Photograph

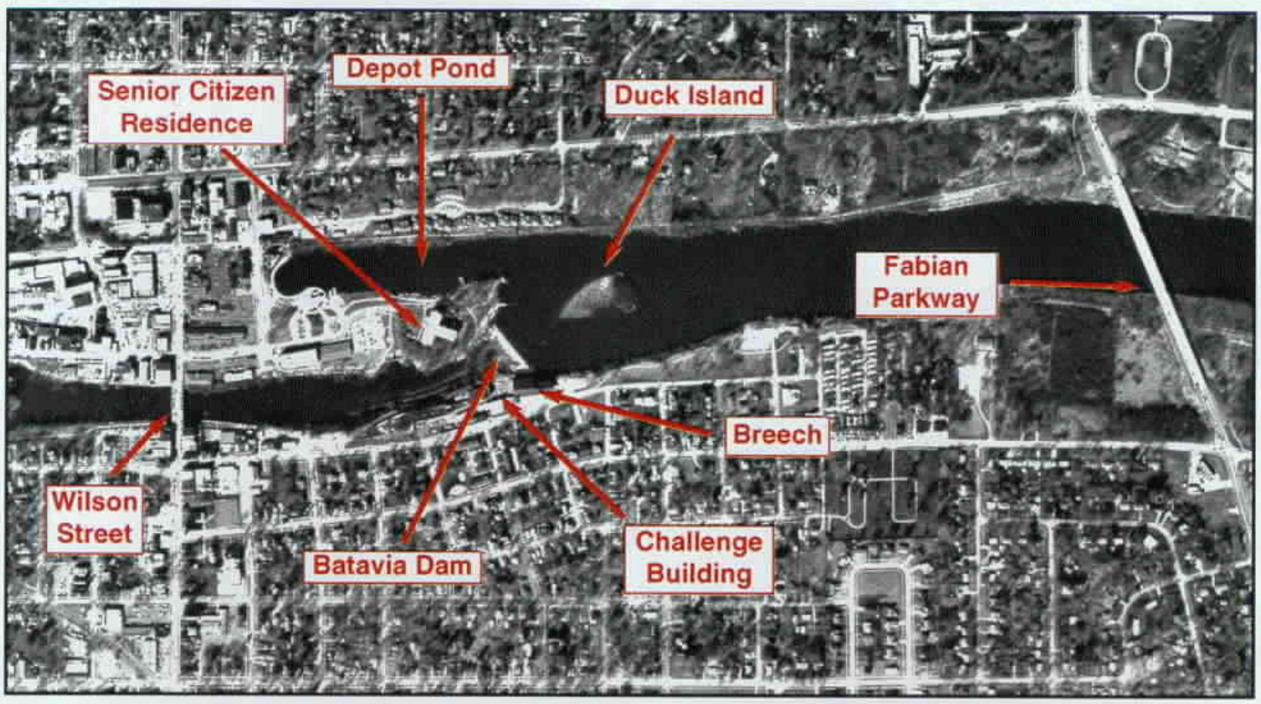


Figure 4 - 1998 Aerial Photograph

BACKGROUND

Site Conditions
Historically the channel bifurcated at a large island (Island 193), which is now a developed peninsula. The left (east) channel was dammed and the right (west) channel was converted to a mill race in the early 1900s. When the mill race fell into disuse, it was filled, leaving the river with only one channel and about half its original width and conveyance. The remaining portion of the west channel is now a dead end and is known as Depot Pond. A small, natural-rock spillway is located just south of the senior citizen residence. This is known as the "Cut" and it conveys minimal amounts of flow from Depot Pond to the downstream reach of the river. The majority of the flow is conveyed through the east channel.

Duck Island, located approximately 400 feet upstream of the dam was created from a natural outcropping of bedrock.

The east end of the dam abutted to the Challenge Building via a "v" shaped concrete retaining wall. The wall collapsed on one leg of the "v", which caused approximately 15 feet of the dam to collapse. The west side is anchored into the bedrock and during periods of moderate flow, water travels down the natural bedrock cascade. The dam itself is approximately 365 feet in length including the breach. It has a drop of approximately 11.5 feet. The crest elevation is at approximately 664.7 feet above mean sea level. A pool is located just below the dam, which was most likely caused by scouring. The thalwag of the channel just upstream of the dam is on the left side (through the breach). The cause of the dam failure is not known at the present time, but the breech is located where a channel or sluice was previously located, and the failure may be related to this previous structure.

Below the dam, the river is constrained to a channel approximately half its historic width. This combined with the proximity of the Challenge Complex, the senior citizen residence, and the City of Batavia government building mandates that there is no allowable increase in flood elevation downstream of the dam. The lack of excess conveyance in this downstream reach severely limits the design team's options and has resulted in several initial concepts to be rendered infeasible.

Approximately 1 mile upstream of the dam is the Fabyan Forest Preserve. A causeway has been constructed from the right river bank to an existing island. This has created a shallow pool just downstream of the causeway.

The grade of the channel below the dam is approximately 0.1%. The grade upstream of the pool is fairly flat at 0.06%.

Utilities
Utilities that may be impacted include a tower supporting 69 kilovolt electric lines located on the Challenge Building property, just downstream of the dam; and several utilities that cross through the Cut, providing various services to the retirement community. Research to determine potential impacts on utilities located within the reach upstream of the dam will be necessary, if one of the dam lowering alternatives is selected.

Site Geology
The dam is founded on nearly flat-lying (easterly dipping) resistant dolomite. This dolomite is thinly bedded and densely jointed. Joints are smooth, planar cracks that interrupt the cohesion of the rock and along which there has been almost imperceptible movement. Typically these

fractures occur in families or sets, of parallel through-going features. Joints form in tension (i.e., a pulling apart) in response to tectonic and thermal stresses that force the rock to extend ever-so-slightly perpendicular to the plane of fracture. Movement parallel to the plane of fracture is negligible. Joints are remarkable in their consistency of spacing and orientation. Major horizontal joint sets are several feet apart. Major vertical joint partings are 2 to 4 inches wide, which are typically filled with fine-grained sediment. Minor joint sets are several inches apart with fine partings.

The dolomite is nearly flat-lying with a gentle dip to the east. Outcrops of the dolomite are visible on both banks of the river. Overlying the dolomite, within the channel area, is a thin deposit of alluvium derived chiefly from glacial deposits. The alluvium is comprised of organic-rich clay, silt, sand and gravel, and cobbles. The thickness of the alluvium ranges from less than one foot to more than 15 feet in the vicinity of the dam.

Previous Studies
A study was conducted by the Department of Civil Engineering, University of Illinois at Urbana-Champaign (Ref. 2) in April 1998. This report discussed 3 alternatives for the replacement of the dam. A physical model was completed for each of the alternatives. All of the alternatives involved replacing the

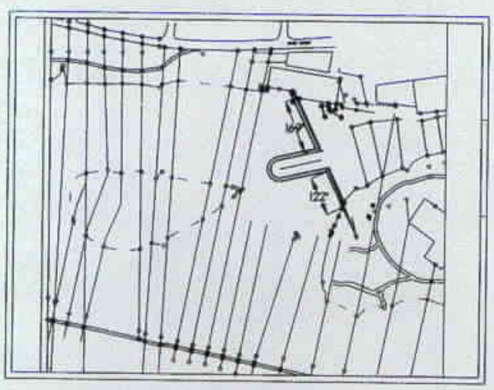


Figure 5 - Bathtub Spillway

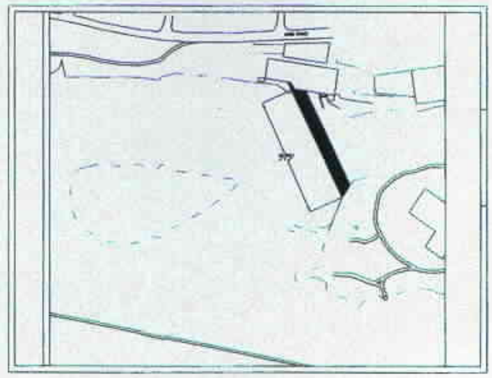


Figure 6 - Rock Dam

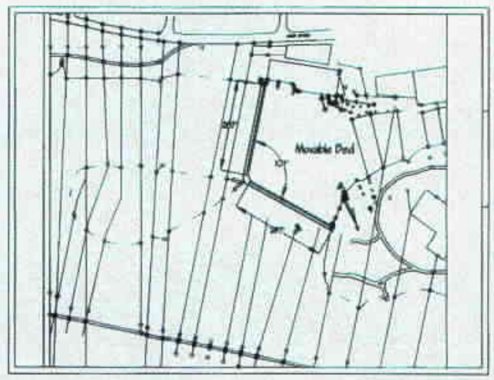


Figure 7 - 2-sided Modified Ogee Spillway

dam, but did not look at incorporating boat and fish passage. They were as follows:

- The "bathtub" spillway - a plan of this is shown in Figure 5.
- The rock dam - this involves replacing the dam with large boulders. It is shown in Figure 6.
- The 2-sided modified ogee spillway - This is represented in Figure 7.

The bathtub spillway and the 2-sided spillway alternatives were focused on redirecting the downstream currents away from the east bank. This was to reduce erosion or erosion potential of the east bank. The modeling effort also included analysis of the approach currents and resulting sedimentation patterns relating to the formation of Duck Island. Although no formal conclusion was made, the 2-sided alignment appeared to be the preferred alternative.

An earlier investigation was completed for the Illinois Department of Natural Resources (IDNR) by a group of consultants, including Wright McLaughlin Engineers. The effort was focused on the addition of whitewater bypasses around this and other dams on the Fox River. The resulting report "Fox River Paddleway" (Ref. 3), dated 1979, outlined two alternatives including a whitewater bypass around the natural rock abutment of the dam on the west end and a whitewater bypass through the Cut. The report did not include integrated dam replacement options.

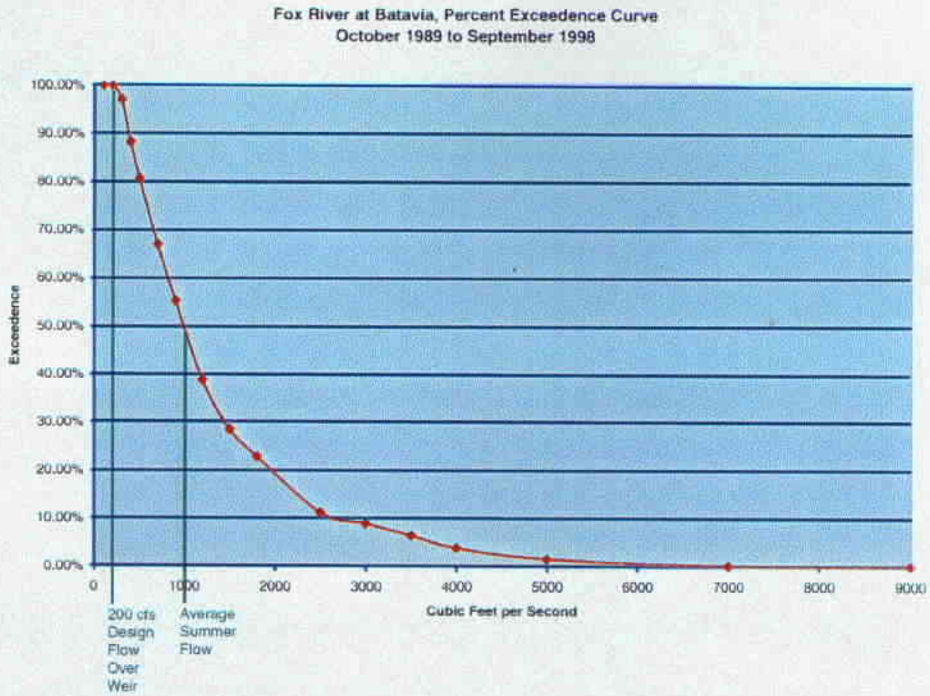


Figure 9 - Percent Exceedence Curve

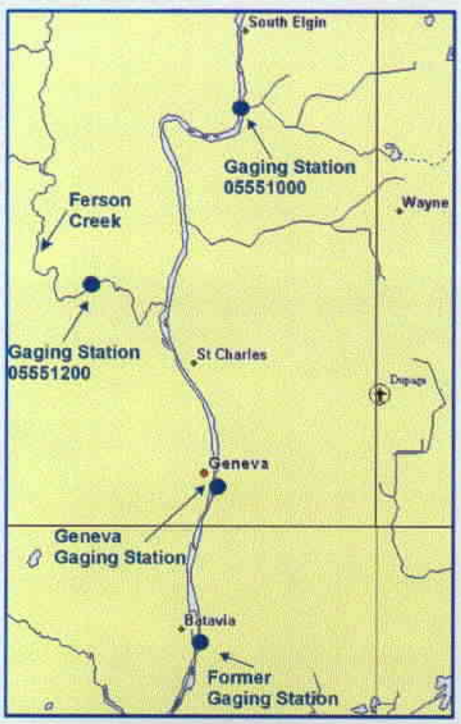


Figure 8- Location of Gaging Stations

Hydrology

Fox River Information from USGS gaging station 05551000, Fox River at South Elgin, located approximately 11 miles upstream from Batavia Dam, was used for its continuous discharge records of 1989 to present to determine design flows at the Batavia Dam. In addition, records for the gaging station at Ferson Creek (station 0551200) near St. Charles were also used. Figure 8 depicts the location of each of these gaging stations. Drainage areas for the above mentioned stations are 1556 square miles (mi^2) at South Elgin and 52 mi^2 for Ferson Creek. The total drainage area for the Fox River at Batavia is approximately 1660 mi^2 (Ref. 4). Daily values from these two stations were added together to estimate the daily flow at Batavia Dam and create a curve denoting the percentage of time various flows are exceeded (a percent exceedence curve, shown on Figure 9). The developed flow values were used to represent an average summer flow and weir design flow.

USGS station Fox River at Batavia, located 0.7 miles upstream from Wilson Street Bridge, operated from 1962 to 1976. This station, the closest station to Batavia dam, was only a partial record-gaging station and therefore daily values are not published. An additional partial record-gaging station exists at Geneva. This station was used by IDNR to develop a rating curve for the flood related hydraulic modeling of this area. Gage records are available from 1962 to present.

Estimates for flood events, including the 100-year and 500-year events, developed by FEMA, are the regulatory flows used for this analysis. Relevant flows used in this alternative analysis are summarized in Table 1.

Depot Pond

For the most part, tributary flow to this reach of the river was not considered relevant to the alternative evaluation and was not analyzed. One exception to this was the basin tributary to Depot Pond. For several of the alternatives it was necessary to make an approximation of the stormwater inflow to Depot Pond. Hydrology for Depot Pond was determined using at a USGS 7.5 minute topographic map to determine the basin size and characteristics, and calculating the runoff conveyed into Depot Pond for the 100-year flood event. The drainage area tributary to Depot Pond is roughly 130 acres. Peak flow to the pond during the 100-year event is estimated to be approximately 450 cfs. This estimate will be refined if inflow to Depot Pond is relevant to the design of the selected alternative.

Hydraulics

FEMA completed a Flood Insurance Study (Ref. 5) in 1981 for the City of Batavia. Cross sections used in this analysis were determined from field survey information and contour information from U.S. Army Corps of Engineers, 1978. IDNR developed a HEC

Event	Flow (c.f.s.)
Design of entrance control weir	200
Optimal recreational flow for the boat/ fish passageway	1000 - 1500
Average summer flow (design of low flow channel)	1000
Bankfull or 1.5 year event (IDNR)	5500
100-yr Flood Event (FEMA)	13500
500-yr Flood Event (FEMA)	17630

Table 1 - Design Flows

RAS model study incorporating cross sections from the FEMA study along with additional survey information completed in 1996. The study reach was divided into two separate models, an upper Fox River (just upstream of the dam) model and a lower Fox River (just downstream of the dam) model. Several model runs were developed based on the original imported information, rating curves, etc. IDNR verified that the new upper model agreed with the corresponding FEMA model in an Illinois State Water Survey, Stream Model Request form, dated November 30, 1999.

MWE combined the IDNR upstream and downstream models into a single base conditions model. The cross section at the dam location was modeled as an inline weir representing the dam and additional flows being conveyed over the bedrock spillway on the river right side. The model simulates a repaired or original dam crest, not the existing dam breach. MWE also verified the water surface elevations at the dam through hand calculations. Results from this model and the manual calculations are included in Appendix A.

Water surface elevations at the dam are summarized below in Table 2.

Just below the dam, the flow is constricted to a narrow channel. This has significant impacts on the alternative analysis because no significant increases in floodplain elevations are tolerable without major and intrusive mitigation efforts. This limits the options for location of new structure such as boat passage, to the reach upstream of the dam and possibly to the reach downstream of the retirement home and the Cut.

Water Quality

The Illinois State Water Survey conducted a study in September 1995 (Ref. 6), which addresses water quality on the Fox River. Five stations along the Fox River both upstream and downstream of Batavia were selected for analysis in the study.
The report concludes that the impoundments throughout the study reach contain high levels of phosphorus, which promote excessive algal growth. The report states that "High nutrient inputs and still-water environments created by the numerous channel dams situated along the entire main stem of the Fox river in Illinois promote excessive algal growths."

Accelerated algal growth results in fluctuations of dissolved oxygen (DO) and pH levels in the water result in environmental stressing or acute morbidity of desirable aquatic life. Although algal-related

STUDY	100-Year Event Water Surface Elevation at Dam	500-Year Event Water Surface Elevation at Dam
1981 FEMA Study	668.2	668.8
IDNR - Imported flow 01	668.2	668.8
IDNR - Based on rating curve	669.0	669.7
MWE - Updated conditions	668.7	669.5

Table 2 - Dam Surface Elevations

photosynthesis may result in increased DO concentrations during the daytime, DO is utilized during the night by the algae and by "consumer" organisms. Minimum DO levels, rather than averages, are more critical to fish survival. A DO level of 4 to 5 mg/l is often cited as the minimum permissible value to maintain a healthy fish population. Also, diurnal pH swings associated with algal growth may increase the toxicity of heavy metal contamination (typically with dropping pH) and ammonia-nitrogen contamination (with increasing pH), further stressing the biota.

Dangers with Dams

The Batavia Dam does not act like a typical ogee crest dam, with an energy dissipating hydraulic jump located at the bottom of the dam. The location of the hydraulic jump for Batavia dam is located further downstream due to a low tail water effect from the downstream channel. This is evident by the large scour hole that has been formed where the hydraulic jump actually occurs and erosion of the downstream left bank. Replacement of Batavia Dam with a "correctly" designed ogee crest dam and without recreational boat passage, could create dangerous hydraulic conditions.

One inherent danger with ogee crest shaped and other low-head dams is the hydraulic conditions that are created at the bottom or on the downstream side of the dam. The

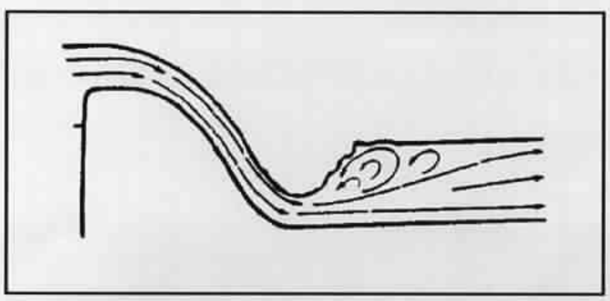


Figure 10 - Cross Section of Ogee Crest Dam

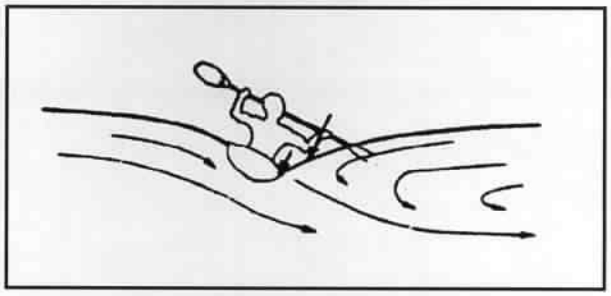


Figure 11 - Upstream Flip

conditions include the formation of dangerous hydraulic jumps with reverse (or upstream) surface currents and very abrupt vertical differentials. This type of hydraulic can trap or hold objects, recreational craft, and people within the hydraulic. Once involved, escape from such a man-made feature is difficult because of the uniformity (linearity) of the structure, often resulting in accidents and fatalities. These types of jumps (often called holes or keepers) occur in natural rivers, but are usually dispersed and non-uniform such that escape is often possible by adjacent and irregular currents.

To further illustrate this concept, Figure 10 shows a cross section of a typical ogee crest dam and the reverse currents on the water surface. Figure 11 shows a kayaker in a very modest 6 to 12-inch (15 cm to 30 cm) jump. The slightest exposure of the kayaker's deck or paddle to the upstream will cause an upstream flip. The kayaker cannot rely on the downstream current, if the surface water is moving upstream because the current will flip his boat downstream if his deck or paddle is exposed. Additionally, this type of hydraulic is uniform across the length of the dam, and the kayaker is trapped. Although warning signs are typically placed upstream of dams, children, fishermen, and boaters have been trapped in these sometimes tranquil-looking currents. Many people have drowned at dams throughout the U.S. and Canada (Ref. 7).

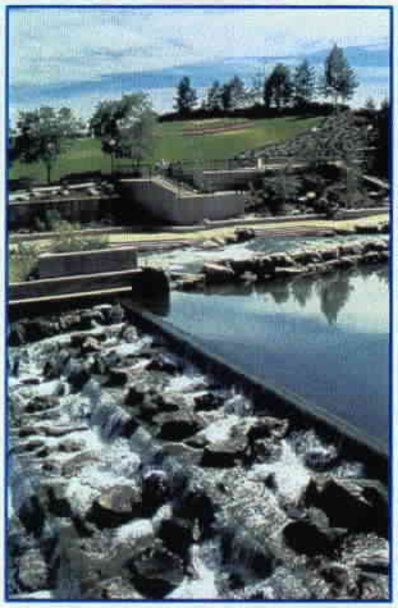


Figure 12 - Stepped Dam

The use of stepped dams has been limited, but several designs have been successful at not trapping boaters and dissipating energy. If the selected alternative includes a dam, a stepped dam similar to that shown in Figure 12 would be used.

Sediment and Dams

Most dams trap sediment or disrupt the natural sediment transport of rivers. The Upper Batavia Dam has a significant volume of sediment within its impoundment. Detailed estimates would require extensive field effort, and none have been completed to date. For the purposes of this report, an estimate was made based upon limited field data and is discussed in further detail in a subsequent section.

Normally low head dams such as the Upper Batavia Dam reach an equilibrium point at which new sediment is passed through and stops accreting. How quickly the equilibrium point is reached, is a product of many factors: the river's sediment load, particle size, gradient of river, size and volume of the impoundment, and height of dam. Unlike

Figure 13 - 1939 Aerial Photograph

Figure 14 - 1970 Aerial Photograph

Figure 15 - 1981 Aerial Photograph

well publicized cases of large western dams that are losing so much storage that they will soon no longer function, low head dams are rarely totally impaired by sediment build up. This is because their relatively short, low volume impoundments allow for manual excavation and high flows can often move sediment through the upstream pool.

Changes in a dam can effect the way it traps sediment. For example, at the Batavia Dam, the breach on the left (east) side caused a change in the flow pattern in the impoundment, favoring the left side. This undoubtedly "sluiced"some sediment in the immediate area of the breach. A more subtle manifestation was noted by the town's people who observed that Duck Island (600 feet away from the dam) began to grow in size due to sediment deposition in the years following the breech. This resulted from changes in flow and eddy patterns. Figures 13, 14, and 15 illustrate how Duck Island has changed over the years. In 1939, prior to the dam replacement, Duck Island has a large build up of sediment deposition on the downstream end. In 1970, after the dam was replaced, Duck Island appears to be much smaller. Then, once again, in 1981, after the breach, Duck Island has grown from sediment deposition.

Approach

Several efforts were completed in the development of the alternatives; initial technical analyses were conducted; design criteria were established; concepts were developed; and finally, the concepts were refined into alternatives.

During the technical analysis, available data was collected and reviewed. In addition, geologic and field surveys conducted by IDNR were reviewed and used to define existing conditions. A fisheries design criteria was developed. This includes criteria for passage of the target species as defined in the fisheries section. A recreation study was also completed and the Comprehensive Plan for the City of Batavia provided assistance in the development process.

Concepts were developed based on past projects completed by the design team and applying them to this site. They were refined, based on the specific criteria and site constraints. In addition, meetings were held with the design team and the city. These meetings proved very valuable in the development and refinement of the alternatives.

Once an alternative is selected, a preliminary design effort is planned to commence. This effort will continue to solicit input from city representatives and include more detailed analysis. The study may also entail a physical model study or a more detailed geotechnical investigation of the channel and deposited sediments. This should be followed by preliminary and then final design.

DESIGN OBJECTIVES

The primary objective of this study is to identify rational concepts for the replacement of the Upper Batavia Dam. Once identified, some evaluation and refinement of these concepts was completed and logical alternatives formulated. To assist with the evaluation of these alternatives, statements of probable costs were created and are presented in a later section. The alternatives offer unique configurations, so criteria other than capital cost needs to be reviewed to aid in the selection of the most appropriate alternative. To assist in this effort, specific design objectives used in the formulation of the alternatives are provided below.

Design objectives include:

- *Safety* - Create a low-hazard structure that does not result in a "drowning machine," as described above.
- *Flood Conveyance* - Maintain or improve the flood conveyance of the existing channel and dam.
- *Upstream Pool* - Maintain an upstream pool elevation of 664.7 ft.
- *Cost effectiveness* - Create alternatives that are integrated and efficiently meet practical criteria
- *Boat Passage* - Include boat passage to allow or promote recreational usage of the river.
- *Fish Passage* - Include effective fish passage.
- *Maintenance* - Reduce maintenance requirements.
- *Environmental Impacts* - Reduce negative environmental impacts associated with construction or design of the improvements.
- *Depot Pond* - Lower maintenance costs and improve water quality.
- *City Planning* - Coordinate and enhance planning and goals of the City of Batavia including those set forth in the Comprehensive Plan for the City of Batavia (Ref. 8).

To develop alternatives that would accomplish these goals, several initial efforts were needed. Basic and available data was collected, including mapping and geologic and field surveys completed by the IDNR. Studies reviewing fisheries design criteria and recreation were initiated. This information was then used to develop alternatives that would address some or all of the design objectives. Summaries of these studies are included in the following sections.

FISH PASSAGE CRITERIA

Fisheries Data
A good understanding of the population and species of fish in this reach is required for an evaluation of dam replacement alternatives at the Upper Batavia Dam. The combination of fisheries science efforts provided by the IDNR and evaluation regarding fishing opportunity along this reach of the Fox River will provide the design team with an adequate base for fisheries engineering and design. The identified study reach extends upstream to St. Charles and downstream to Aurora. The results summarized in this report may be applicable to other regions beyond this particular reach.

Data Collection
Fisheries biologists conducted an extensive site visit in January 2000. During this visit, above surface fish habitat, river corridor and riparian areas, visible bottom and substrate conditions, as well as other pertinent fish habitat characteristics were observed and recorded. Retail fishing tackle shops were visited and owners interviewed. Fisherman on the river were observed and interviewed. Various other individuals were also interviewed about sport fisheries aspects of the Fox River.

The IDNR provided detailed fisheries science data that has been reviewed. A species list is included in Appendix B and it should be noted that most of this work is "work-in-progress". Fish swimming speeds for target fish are presented in Table 3 as provided by Bell, Fisheries Handbook, 1991 (Ref. 9 - 28).

Fox River Fish Passage Feasibility Study
A joint study of this region of the Fox River is currently being conducted by the Max McGraw Wildlife Foundation, and the U.S. Environmental Protection Agency, and is being funded in part by the Illinois Department of Natural Resources. The objectives of the study are to determine the effects of the Fox River Dams on fish populations, macroinvertebrate populations, physical habitat, and water quality. In addition, the study is to outline options for dam removal or modifications to enhance fisheries, water quality and river based recreational activities.

The Max McGraw study includes analysis of species richness, index of biotic integrity, the harvestable sport fish and habitat quality index (QHEI). Included below are preliminary results that were presented by Vic Santucci on behalf of the Max McGraw Wildlife Foundation during the public meeting held on October 23, 2000. These preliminary results are included in this effort because of the lack of detailed fish habitat and population information currently available for this section of the Fox River. The initial information in the Max McGraw study provides a portion of that much needed data. The reader is advised to note that this work is in-progress and preliminary.

As shown on Figures 16,17,18, 19, 20 and 21, early results identify that fish habitat in the reach below the dams is more diverse and of higher quality than habitat found above the Dam at Upper Batavia. This result holds for other reaches of the Fox River. In terms of fisheries habitat, these data appear to support the idea that dam removal would enhance fisheries habitat

Figure 17 represents the index of biotic integrity. This index has been used assess the biological quality of rivers and streams throughout the United States. It compares the structural and functional components of the fish community with those from

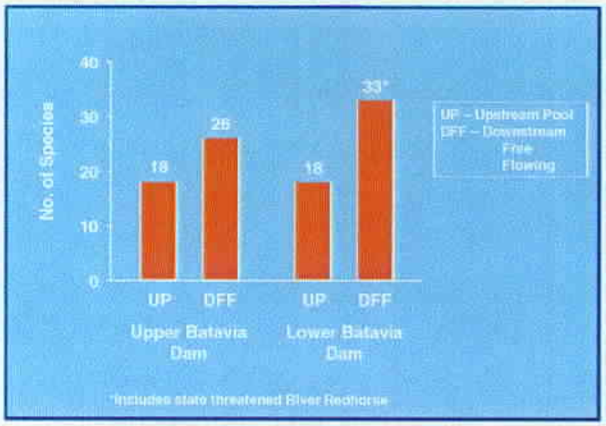


Figure 16 - Number of Species of Fish Found in the Upstream and Downstream Reaches

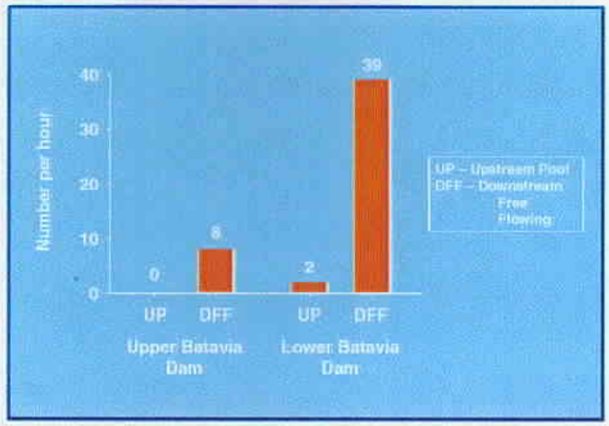


Figure 19 - Number of Channel Catfish

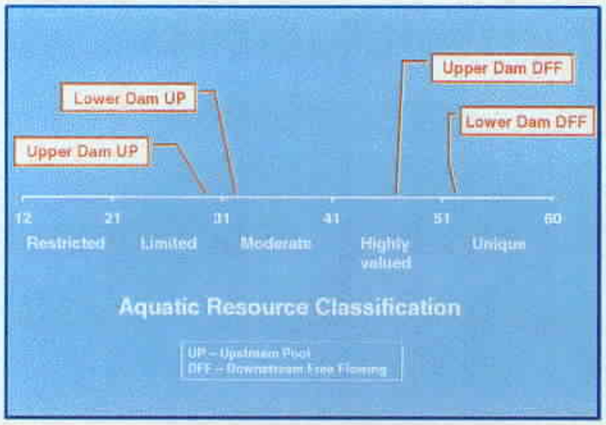


Figure 17 - Index of Biotic Integrity

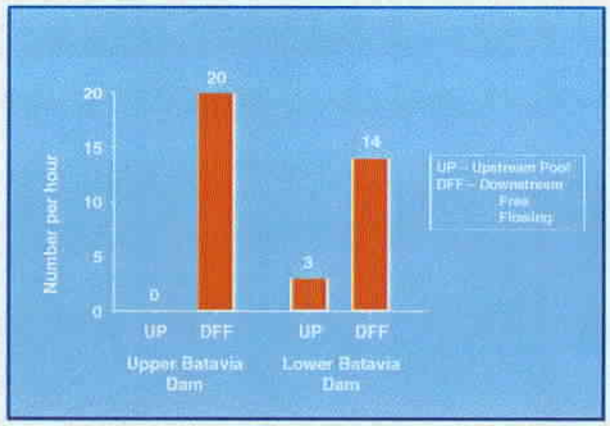


Figure 20 - Number of Smallmouth Bass

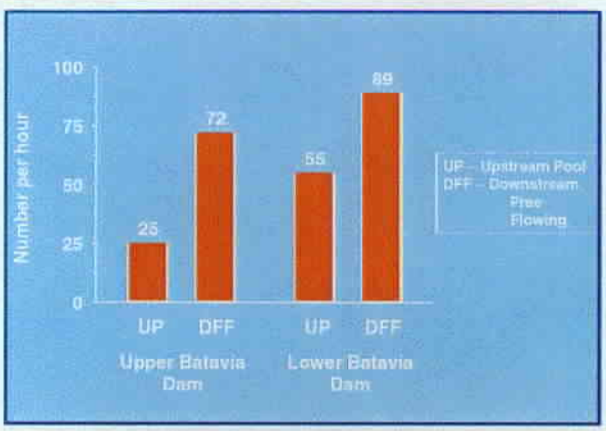


Figure 18 - Harvestable Sport Fish

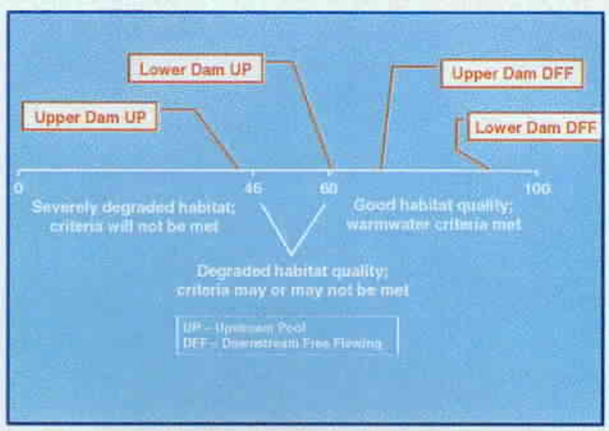


Figure 21 - Habitat Assessment QHEI

unaffected or minimally affected communities from ecologically similar areas. It looks at species richness and composition, trophic structure, and fish abundance and health.

Figure 21 is an assessment of the qualitative habitat evaluation index (QHEI). This is a macrohabitat evaluation index developed and used by the Ohio EPA to evaluate habitat quality in streams and rivers throughout Ohio. The QHEI is composed of six metrics that describe attributes of physical habitat that may be important in explaining species presence or absence and general fish community composition in a section of stream or river. The metrics assessed are substrate, instream cover, channel quality, riparian quality, pool/riffle development and gradient. QHEI scores have been shown to correlate well with IBI scores demonstrating the utility of this habitat evaluation procedure (Ref. 29).

<u>Species List</u>
The "Fish Species List" for Fox River Mainstem Collections -- IDNR database 1979 -- 1996" (Appendix B) identifies all known fish present in this reach of the Fox River. Included in this list are species that are noted to be both weak swimmers and strong swimmers as related to the fishes' abilities to pass through rapids, chutes, or fish ladders. It also includes species of fish that Steve Pescitelli, stream ecologist with IDNR, noted as being host to several species of mussels found in the Fox River that are threatened or endangered.

<u>Threatened and Endangered Species</u>
There are no federally-recognized, threatened or endangered species found in this reach of the Fox River. However, there are two species listed on the Illinois state threatened and endangered species list: the River Redhorse (*Maxostoma carinatum*) and the Greater Redhorse (*Maxostoma valenciennesi*). Fish passage opportunity must be provided for these two species across the multi-purpose Upper Batavia Dam or any other facility along the reach.

<u>Identified Habitat</u>
There are several forms of fish habitat located in this reach of the Fox River. Above the upper Batavia Dam, there is a large pool of slow-moving impounded water that has very slow river velocities and contains many backwaters and non-moving waters and mostly a fine sediment bottom. The area above of the upper Batavia Dam is poor habitat for sucker species and smallmouth bass and other game species, although some crappie may exist. Forage and dissolved oxygen is poor for sucker and game species in this section. Around Duck Island there are sandy beaches and gravel patches of riverbed indicating some river velocity.

Below the Dam, the river has substantial velocity and exhibits large cobble and bedrock runs. Along the existing bedrock that forms the right bank abutment of the dam, there is a gravel point bar formed because the deep section of the river is along the left bank in this area. Gravel riffles and deep runs persist downstream until the backwater of the Lower Batavia Dam slows the velocities to speeds that deposit fine gravel and sand. The river channels around several islands in the City Park where several foot bridges cross and large woody debris from fallen trees provide habitat for Smallmouth Bass, Walleye, and a rare Muskellunge (personal communication with fisherman at the City Park).

The reach around the dam is typical of each of the dams located along the Fox River. In general the habitat is similar and consists of an impounded pool, a dam, plunge pool below the dam, deep runs with a tail-out forming-into a riffle, and the next back water from the dam downstream. It should also be noted that the deep pool directly below the Upper Batavia Dam provides a summer low flow refuge for certain species. The plunge pool also experiences times of low dissolved oxygen at which time it is not habitable for most species present.

Sport Fishery

There exists an extensive sport fishery observed during the initial site visit in January. Sport fishermen were fishing near the dams at both Geneva and Batavia. Extensive fishing occurs downstream of the Upper Batavia Dam in the City Park adjacent to the wastewater treatment plant. The fishermen that were interviewed spoke about catching Muskellunge, Smallmouth Bass, Walleye, and other sport species.

All of the fishermen interviewed were very enthusiastic about the fishery in this reach of the Fox River and fish extensively year-round. Therefore, there is a value associated with maintaining this fishery, which would include continued fish passage upstream and downstream across the dam or the area where the dam is located to insure a healthy population. In addition, habitat enhancement structures, such as large woody debris, enhanced habitat structures, and large rock formations could provide additional habitat that is presently limited along this reach. This type of enhancement could also be utilized for mitigation purposes.

Age Composition of Local Fish

The age composition of fish species found around the upper Batavia Dam varies widely. Data is not available at this time for inclusion into this report describing the age composition of identified fish. Costs associated with upstream fish passage for juveniles of any of the species would result in a very flat sloped and expensive constructed system. The young of all species present do not show a strong tendency to migrate and are therefore not likely to ascend a fishway or constructed system that is outside their abilities of swimming. For this reason, the juvenile fish are not considered as specific "target fish" for passage. Specific juvenile species will incidentally be able to pass upstream but are not identified in the report. (However, juvenile fish of most species will be able to pass over the restored river channel as described in Alternative 4a and other select juvenile species will be able to cross the other Alternatives as provided in the swimming speeds shown in Table 3).

Population Trends

Of the fish species that are commonly found in this reach, strong migratory behaviors are rare. The fish species present migrate due to population forces more than the dynamics of spawning migrations such as is found in some salmonid species. Table 4 shows typical spawning and migration patterns for fish in this reach. A weak migration behavior creates a more difficult passage solution for these fish species across a formal fishway or a multi-purpose dam. However, research shows that fish passage does occur in conventional type fish passage arrangements for some of the species known to exist in this reach.

Population dynamics such as overcrowding, low food resources, and the pressures of territory may cause certain species to migrate. Another behavior is that of straying simply to proliferate offspring into other habitats and niches in the reach. In addition to this behavior, several species of fish provide a commensal benefit to certain species of mussels found in the Fox River. Current fish passage criteria will provide passage for the sucker species thus allowing for a continued commensal relationship between the fish and mussels.

Table 3 - Fish Swimming Speeds

MIDWEST FISH SPECIES		*SWIMMING SPEEDS feet/second*					*References*
		Adult			Juvenile		
Common Name	Scientific Name	Cruising	Sustained	Darting	Sustained	Darting	
Quillback	*Carpiodes cyprinus*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
River carpsucker	*Carpiodes carpio*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Highfin carpsucker	*Carpiodes velifer*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
White sucker	*Catostomus commersoni*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
White sucker (7-16")	*Catostomus commersoni*	0 to 3	3 to 5	5 to 10	1 to 3.5		USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Northern hog sucker	*Hypentelium nigricans*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
River redhorse*	*Moxostoma carinatum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Greater redhorse**	*Moxostoma valenceinnesi*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Shorthead redhorse	*Moxostoma macrolepidotum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Golden redhorse	*Moxostoma erythrurum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Silver redhorse	*Moxostoma anisurum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Goldfish	*Carassius auratus*		1 to 3.5	3.5 to 6	1 to 2		USACE Fisheries Handbook, Pg. 6.5
Trout Perch	*Percopsis omiscmaycus*			3	1.5 to 2		USACE Fisheries Handbook, Pg. 6.5
Emerald shiner (2.5")	*Notropis atherinoides*			4	1 to 3.5		USACE Fisheries Handbook, Pg. 6.5
Green Sunfish	*Lepomis cyanellus*			6 to 10			Webb 1975
Bluegill Sunfish	*Lepomis machrochirus*			2.5 to 4.3			Webb 1978a
Crappie	*Pomoxis annularis*			1.1			
Yellow Walleye (9-16")	*Stizostedion vitreum*				1 to 3		USACE Fisheries Handbook, Pg. 6.5
Smallmouth Bass	*Micropterus dolomieu*						USACE Fisheries Handbook, Pg. 6.5
Channel Catfish	*Ictalurus punctatus*		1.5				Watenpaugh and Beitinger, 1985
Largemouth Bass	*Micropterus salmoides*						Webb 1986b
Muskellunge	*Essox masquinongy*			3			
Pike (14")	*Essox lucius*			11	1 to 4	4 to 8	USACE Fisheries Handbook, Pg. 6.5
Pike (15")	*Essox lucius*			13			Harper and Blake 1991
Flathead minnow (2.5")	*Pimepales promelas*			2.6			Webb 1986b
Yellow Perch (6")	*Perca flavenscens*			3.7			Webb 1978a
Longnose sucker (4-16")	*Catostomus catostomus*			7	1 to 3		USACE Fisheries Handbook, Pg. 6.5
Goldeye (9")	*Hiodon alosoides*			4	1 to 2.5		USACE Fisheries Handbook, Pg. 6.5

TARGET FISH SPECIES		*SWIMMING SPEEDS feet/second*					*References*
		Adult			Juvenile		
Common Name	Scientific Name	Cruising	Sustained	Darting	Sustained	Darting	
Non-Game spp.							
River carpsucker	*Carpiodes carpio*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Highfin carpsucker	*Carpiodes velifer*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Northern hog sucker	*Hypentelium nigricans*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
River redhorse*	*Moxostoma carinatum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Greater redhorse**	*Moxostoma valenceinnesi*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Shorthead redhorse	*Moxostoma macrolepidotum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Silver redhorse	*Moxostoma anisurum*	0 to 3	3 to 5	5 to 10			USACE Fisheries Handbook, Pg. 6.3 (for Suckers in general)
Game spp.							
Walleye (9-16")	*Stizostedion vitreum*				1 to 3		USACE Fisheries Handbook, Pg. 6.5
Muskellunge	*Essox masquinongy*			3			
Channel Catfish	*Ictalurus punctatus*		1.5				Watenpaugh and Beitinger, 1985
Pike (14")	*Essox lucius*			11	1 to 4	4 to 8	USACE Fisheries Handbook, Pg. 6.5
Pike (15")	*Essox lucius*			13			Harper and Blake 1991

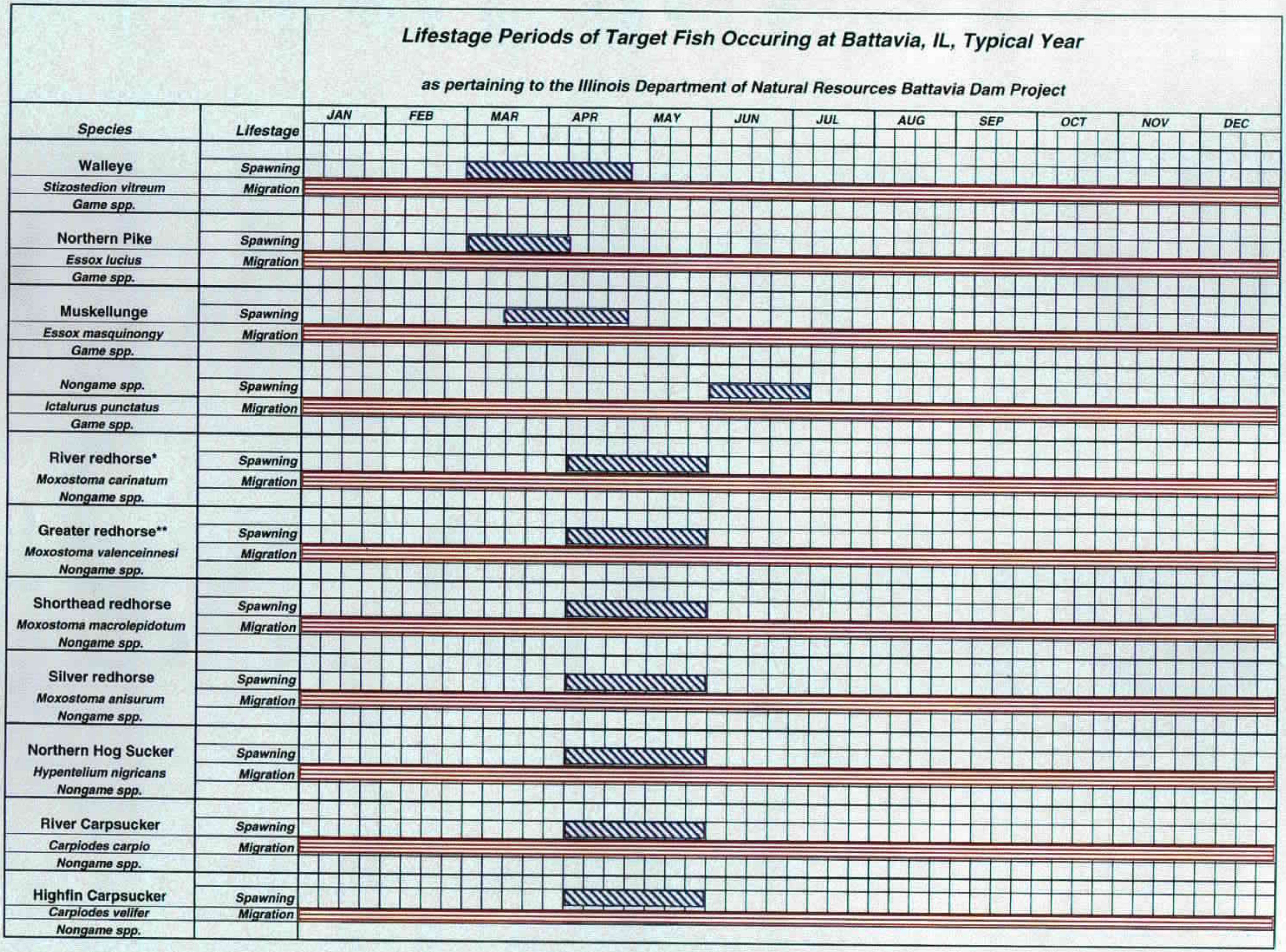


Table 4 - Typical Spawning and Migration Patterns

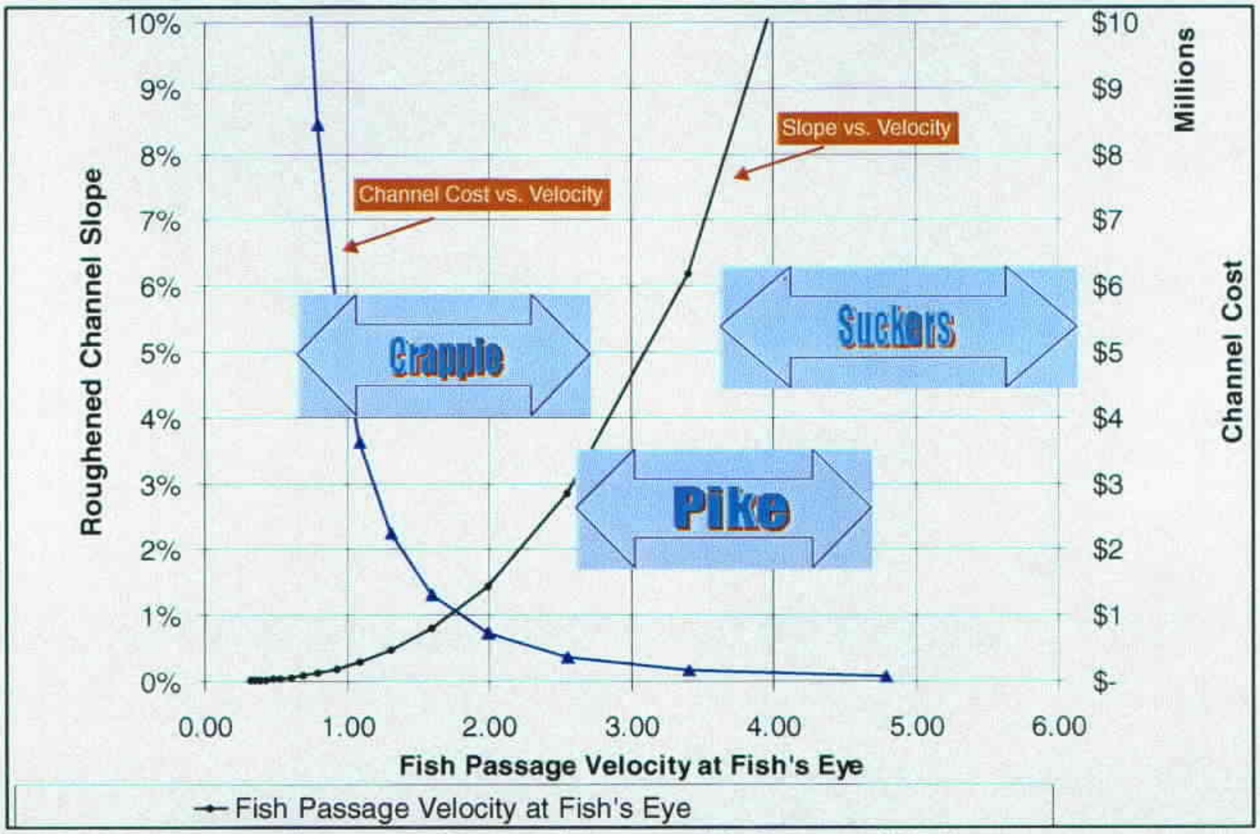


Figure 22 - Slope and Cost vs. Fish Passage Velocity
for a Roughened Channel at Batavia, Illinois

It is also possible that local fish migration may occur or be developed due to fluctuating dissolved oxygen levels or temperatures in the various pools and shallow riffles along the Fox River.

Fish Passage Criteria

Engineering and Fisheries Engineering Criteria

Our approach considers several alternatives of project geometry. We have developed the concept of the "fish's eye" velocity. This water velocity is what the fish experiences during its passage through the areas it will use to swim over the project. The fish's eye velocity is approximately 0.51 times the channel mean depth velocity. Using Manning's Equation to solve for various velocities of water over different slopes and geometry, we developed a generalized chart showing the relationship of slope, velocity and ultimate costs of using a roughened channel at the Batavia Dam site. Figure 22 depicts a range of darting swimming ability for selected target species. The target species darting swimming speed is the governing velocity that is utilized for designing fish passage systems.

The fisheries engineer utilizes a range of velocity to design fish passage pathways. The darting velocity is taken as a reported value from various references, in particular, Bell 1991 and others as referenced. The sustained velocity is defined as 0.5 times the darting velocity. Using these two velocities as a range, the fish passage project is established to provide a continuous pathway with a water velocity that fits within this range. This allows fish to swim up through

Item	Criteria
Maximum Vertical Water Step for Fish Pathway at Structures	12"
Maximum Local Percent Bed Slope	5%
Anticipated Average Percent Bed Slope	<1%
Minimum Flow Depth	8"
Minimum Pool Depth	48"
Fish Passage Low Flow Rate,	Qlow2-Year, 7-Day Low, QLow = 288 cfs
High Passage Design Flow Rate, QHP	100-year peak event 6,740 cfs
Exceedence Design Flow Rate	Q80% exceedence 500 cfs
USGS Reference, Web Site	Q50% exceedence 965 cfs
Gauge 05551000	Q20% exceedence 1920 cfs
Minimum Instream Flow	222 cfs

Table 5 - Fish Passage Criteria

the passage pathway. This is known as a fish passage opportunity and is provided by the physics and geometry of the project and the water flow.

Certain species of fish may wish to ascend the project and others will not. The behavior and willingness of the fish all relate to the success or quantity of passage. Some fish, for various reasons are not as motivated to ascend fish passage areas or structures and these fish will not have as high of passage frequency. At the Upper Batavia Dam project, these fish may include some of the crappie and sunfish, northern pike and the muskellunge. However, the velocities of all alternatives will be passable for the weakest species of adult swimmers such as the crappie. Juvenile fish tend to exhibit lower darting velocity and some passage limitation will exist.

As can be observed in Figure 22, costs for fish passage dramatically increases depending upon the fish passage criteria selected. This figure is based on a cost of $900/per lineal foot. This cost could represent a separate roughened fishway channel or for that portion of a multi-use whitewater channel. In any case, it is resented for illustrative purposes only.

Table 5, above, represents the fish passage criteria used by the design team.

Target Fish Species List and other Biological Criteria

Given the large number of fish species present in the Fox River, target species were reduced from the large list of local species, to those groups and/or species of concern due to their importance, endangerment, or value to sport fisheries. With assistance from IDNR, a target list of species to provide fish passage across the dam was developed and is shown in Table 6. It is a working list and maybe edited as required. The design criteria developed in regard to these species will be compared with requirements of other species to ensure there are no adverse impacts to other species not listed in the target list.

The above-mentioned criteria are used by the fisheries engineer to assist the design

Game Fish Target Species:	Non-game Target Species:
Northern Pike	River Redhorse*
Walleye	Greater Redhorse**
Muskellunge	Shorthead Redhorse
** State Endangered Species * State Threatened Species	Silver Redhorse
	River Carpsucker
	Highfin Carpsucker
	Northern Hog Sucker

Table 6 - Target Species

team to develop a project geometry that will provide fish passage for the target species. Utilizing this criteria provides water depths and velocity that will allow the target fish species to ascend and descend past the Upper Batavia Multipurpose Dam. They were chosen on the basis of the size and species of fish found at the site and in the reach. The criteria were also selected considering the goal for fish passage at the project.

Conclusions

Utilizing these project criteria and an understanding of the target species present, the design team can formulate integrated alternatives that meet project objectives. After an alternative is selected the details of the fish passage structures and project geometry including length, slope, and flow capacity of the areas where fish passage may occur can be completed in the final effort.

Roughened channel approaches to fish passage are often the best system to meet the design criteria because they mimic the natural channel and habitat. It also provides for resting areas and areas of lower-than-criteria water velocities in and amongst rocks and boulders. Because of the inherent integration with whitewater passage, roughened channel passage is incorporated into the various multi-purpose dam replacement alternatives.

RECREATION

Design objectives address river-based recreation, recreation on Depot Pond, and land-based recreation.

River-based Recreation
The Fox River provides for a range of recreational boating: small power boats including jet skis, fishing, canoeing, and limited whitewater boating. A notable event on the Fox River is a marathon canoe race from St. Charles to Aurora, passing through the project site at Batavia.

Motorized Craft
Batavia Park District maintains a good river access point for motorized craft a short distance above the project site at Laurel Wood Park (formerly the Batavia Boat Club property). Facilities include a multi-purpose building, boat ramp, and parking, including spaces for trailers. There is another boat ramp at the Kane County Forest Preserve near St. Charles. There is no limit on the power rating for craft within the Batavia impoundment [verify]. The impoundment, however is relatively short and shallow compared to other reaches of the Fox River to the north and south, so the demand is weaker here (Ref. 30).

Canoe/Kayak
The St. Charles to Aurora marathon canoe race is in its 40th year. This event regularly attracts hundreds of participants as well as spectators along its 8-mile route. Other marathon canoe events include the "Current Buster" race from St. Charles to Big Bend Islands and back and a race from Montgomery to Yorkville, both in the spring.

Marathon events are held on mild gradient rivers. The governing body for the marathon is the United States Canoe Association (USCA) that states that competitive events should be held on "waters ranging from flat Class I to Class II river rating, with straight-forward rapids and wide, clear channels according to the International Scale of River Difficulty." (Ref. 31). Portages at dams or more difficult rapids are needed.

Noncompetitive recreational canoeing and float fishing is also popular. However, a quantitative or qualitative analysis of the river resource for this use is beyond the scope of this project. This work focuses instead on the potential impact of the dam replacement.

Accommodations for marathon and non-whitewater recreation will include a convenient portage around the rapids and man-made obstructions such as dams and diversions.

Whitewater Canoe/Kayak
Whitewater kayaking and canoeing is very limited in this vicinity of Illinois. The existing Batavia Dam is one of the few potential resources in the immediate area. The dam was identified as a prime site for a whitewater course in the Wright McLaughlin report of 1979. The present use is a practice site for moving water skills in the riffles and eddies below the dam. At low water some individuals run the dam breach on the left. At higher flows this is too dangerous and the dam is negotiated on the right over the natural bedrock ledge (Ref. 32).

Chicago area whitewater boaters must travel in order to enjoy their sport. The following table shows the "local" whitewater boating venues and (non rush hour) travel time from Chicago:

East Race Waterway, South Bend, IN	**2 hours east**
Vermilion River, Illinois	**2-1/2 hours south**
Big Pine Creek, Illinois	**3+ hours south**
Wolf River, Wisconsin	**4-1/2 hours north**
Red River, Wisconsin	**4-1/2 hours north**
Peshtigo River, Wisconsin	**4-1/2 hours north**
St. Francis River, Missouri	**4-1/2 hours southwest**

Also, available is surfing on the south shore of Lake Michigan after a period of north winds.

Whitewater competitions are unknown in the immediate area. The East Race at South Bend Indiana is the closest site and there are also competitive events at Wausau, Wisconsin. Both of these have hosted slalom races and whitewater rodeo events.

Accommodations for recreational boating should include:

- Rapids rated Class II or Class III, depending on flow
- Parking area and boat launch
- Changing facilities and bathrooms

Slalom

Whitewater slalom is a one to three day event in which competitors negotiate a 300 plus meter whitewater course through a series of gates. The governing bodies for slalom are American Canoe Association and USA Canoe/Kayak. If a whitewater rapid of sufficient caliber was provided there could be at least one sanctioned event per year at Batavia (Ref. 33). Sanctioned events could include:

- Eddie Bauer Whitewater Series
  early summer
- National Slalom Championship
  June to September
- National Open Boat Championship
  June to September
- Junior/Senior National Championship
  June to September
- World Cup International Race
  late June to September

Accommodations for slalom events include:

- Seating areas along the shore (could be grassy slopes or terraces cut into the rock) would serve for marathon events (above) and rodeo events (below).
- A course of 300 meters with continuos rapids (minimum Class III for World Cup, Class II to III for others).
- Electricity on site.
- A parking plan or shuttle system to get spectators to the site for crowds of 2000 or more.

In addition to the above, a slalom training site could be established by a local paddling club if they could maintain a set of slalom gates on part of the rapid. The gates should be able to be moved off the river when not in use or be located in a side channel out of the way of the main stream of river traffic. Permanent restroom facilities should also be added to support more continuos, lower-volume usage.

Rodeo

Whitewater rodeo is a relatively recent but fast-growing event that attracts a crowd. Competitors perform freestyle "moves" in river hydraulic and wave formations and are awarded points by a panel of judges. The governing body for rodeo is the National Organization of Whitewater Rodeos (NOWR). Freestyle rodeos require very specific hydraulics in order to attract an important event—the better the feature, the higher probability of getting an event. With dam-regulated flow a fixed hydraulic feature will do, however with unregulated flow as at the Fox, a variable configuration feature would be needed. An example of a variable configuration feature is an inflatable rubber dam. Such a feature might be incorporated into the dam crest if modulating flow was needed, otherwise it would be an add-on feature, paid from another funding source (such as an event sponsor).

Rodeo events include:

- Team Trials - *spring to early summer*
- World Cup - *mid-summer to autumn*
- World Championship
- Whitewater festival or sponsored event - *mid-summer*

Facilities for rodeo events are the same for slalom except that there must be a reliable, top notch surfing feature. A surfing feature of nearly any description will be appreciated by private, noncompetitive boaters and a good feature will draw boaters from a large area.

Open Deck Canoe

Open deck canoes for the purpose of discussion are non-whitewater open canoes without floatation.

It is popular on free flowing rivers as well as impounded areas of rivers and on lakes. Canoeing is relatively easy and requires little experience. The problem on impounded rivers, however is the danger at low head dams. Lack of knowledge of the dangers of dams and inexperienced boaters has sometimes resulted in drowning when boaters attempt to run dams and capsize. A survey has not been made to establish usage figures for open canoeing on the Fox River. River trails are a popular concept where rivers are promoted as recreation destinations for point to point travel, especially by open deck canoe. River trails are established by having marked access points with convenient facilities and by promotion and information: signage, literature, and web sites. Having a boatable structure and a portage trail in place on or around a low head dam at Batavia would add value and interest to a river trail as well as improve safety.

Recreation on Depot Pond

Depot Pond has been developed into a fine urban park with walkways, river walls, overlooks and a service building. Summer activities include paddleboat concession, fishing, model boat competitions in addition to shore-side strolling and enjoyment. Winter activities include ice fishing and skating. Power boats and jet skis are not excluded from the pond, however they do not frequent the area (Ref. 30). The pond does require dredging and maintenance and was recently cleared of sediment and wooden debris.

Land-Based Recreation

Batavia Parks Districts in conjunction with other park districts in the area have developed an extensive trail system along both shores of the Fox. Bridge crossings for trails are generally on existing vehicular bridges, though a dedicated hike/bike bridge was installed a few city blocks below the project site. The trails are generally 10-foot wide asphalt travel lane with gravel shoulders. The only gap in the trail system is through the Challenge property, adjacent to the project site.

As part of this project the design team has considered:

- Extending the hike/bike trail through Challenge property, preferably along the river's edge.
- Creating a route for a pedestrian/bike bridge connection across the river at the new dam.

PLANNING

The City of Batavia has a comprehensive plan, which sets forth goals for the City and specific objectives to achieve these goals. As it relates to the project at hand, the goals seek to improve the quality of the downtown core next to the river, to improve recreation opportunities, and take advantage of the natural landscape including the Fox River.

Specific open space and recreation objectives to achieve these goals are listed below:

- Respect the natural features of the Batavia landscape, including the topography, river, creeks, flood plains and wetlands.
- Preserve scenic views of the Fox River and other key features.
- Encourage continued development of recreation potential of environmental corridors including the Fox River, Mill Creek, and the Prairie Run.
- Expand recreation activities on and along the Fox River. Consider limited boating activities in tandem with the Fox River Paddleway and canoe portage improvements. Expand pedestrian and bicycle river trails to promote recreation.

Additional objectives for the project area of Downtown Batavia that mention the Fox River:

- Maintain government uses on the island.... Integrate riverfront improvements with continued redevelopment efforts.
- South of First Street, consider appropriate adaptive reuse of the abandoned industrial structures along the river where feasible. Consider commercial uses, especially those that complement recreational activities along the river.
- Encourage multifamily development along the east side of the river north of Spring Street to Fayette Street. If feasible and appropriate, save existing underutilized structures for reuse.
- Upgrade the quality of the riverfront and encourage capturing its potential recreational and commercial opportunities. Encourage implementation of the recently prepared Batavia Riverwalk Plan. Continue developing river trails for pedestrian and bicycle use. Improve the Mill (Depot) Pond area in accordance with overall plans for the river.
- Ensure that the new development sensitively and appropriately incorporate the river as an amenity in the downtown.

Impact of Planning Considerations
The planning objectives seek to incorporate the river as a focus for appropriate commercial and residential development and as a cornerstone for recreational development. In this aspect, they are fairly modest—they do not envision a tourist destination such as a San Antonio Riverwalk or a whitewater venue as at South Bend, Indiana. This may be due, in part, to traffic and parking problems in the downtown core and the need to manage through traffic (a second vehicular bridge across the Fox is being studied). More importantly there is the desire to keep the downtown riverfront area low key and consistent with providing goods and services for Batavia residents, as opposed to visitors.

Walkways and trails near the river and sensitive land-side development is important. However the goals are fairly vague for the river itself--"limited boating activities and canoe portage improvements." Batavia Dam is not directly mentioned, however the Mill (Depot) Pond area is. The later has been improved handsomely since the planning report was last updated. The Riverwalk has also been completed within the project area. Additional specific requests from the first meeting with the town include:

- A trail connection through the Challenge Property in conjunction with major improvements and adaptive reuse of its buildings.
- A second bicycle bridge crossing near the dam.
- Avoid disturbing any of the extant Riverwalk improvements (much of the paving was done as a community).
- Do not introduce bicycle traffic to the retirement home area.

The whitewater boating aspect of the dam replacement raises the bar somewhat for the city on the level of river activity. Therefore, its impact needs to be considered. For example, there will probably be the need for more parking and services to non-Batavia residents. The dam replacement plan therefore will identify areas, preferably away from the island, where these will go.

The project is also an opportunity to improve aesthetics and recreation opportunities for both land-based and water-dependent recreation. It is important to keep things in perspective--some of the early ideas for a whitewater course through the middle of town were inconsistent with planning goals because they introduce too much activity onto the island. Increased river activity in the right intensity, however could advance some of the stated planning objectives in promoting growth in neighborhoods where it is needed:

- Increase the likelihood of the Challenge Property redevelopment
- Add value to the properties along North River Street, increasing their value for new multi-family residential.
- Combined with removal of Lower Batavia Dam this project would strengthen the "Paddleway" by removing the hazards of low-head dams in this reach of the Fox. The continuos river trail could stimulate growth in the riverfront district and in particular, the abandoned industrial buildings on the south end of the city.
- Increased recreational use of the river would enhance appreciation for the river, increase the desirability of all riverfront properties and encourage recreation-related businesses to locate there.

All of these objectives were taken into account during the alternative development phase.

CONCEPT DEVELOPMENT

The alternatives developed and presented later in this report are adaptations of general concepts for a multi-purpose dam. The four concepts presented in this section have been analyzed and implemented by the design team on various sites. These concepts have been developed into facilities that have been proven successful in both physical models and on actual prototypes.

In general terms, no one concept has proven better or more economical than any other. Each site where multipurpose dams or grade control structures have been used is unique. The following factors influence the viability of certain concepts and have influenced the basic concept selected at various sites.

- *Site Constraints* - Location and elevation of buildings, bridges, etc.
- *Available Land* - Adjacent and available land is often needed or beneficial for siting of the new (usually larger) facilities.
- *Funding* - Funds are often not available at the necessary time for some concepts.
- *Fish Passage* - The need to provide for fish passage can greatly increase the cost of various concepts or eliminate the effective implementation of some concepts.
- *Boating Difficulty* - Like fish passage, a lower gradient water course is easier to negotiate than a steeper passage. Cost of boat (or fish) passages are usually directly proportional the length of the facility. Therefore, the cost of implementation of a concept is also directly proportional to the gradient and the difficulty.
- *Floodplain* - Adjustments in the local floodplain elevations needed at some sites may be more suited to certain concepts than others.
- *Utilities* - Interference of major utilities at some sites such as gravity sewers, water mains, and high voltage electric lines can dramatically increase the construction costs of the various concepts.
- *Accessibility* - Sites located in urban settings need a lower level of hazard or difficulty than remote sites.

The following Project Alternatives section includes details of how the following multi-use dam concepts have been applied to the Batavia Dam replacement effort. This section introduces the general concepts of developing a multi-use dam.

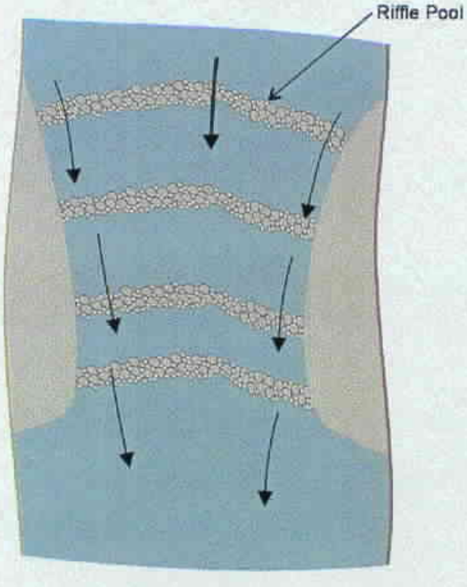
The concepts discussion below is divided into five topics:

- General Description
- Fish Passage
- Recreation
- Management
- Examples

Concept A ~ Natural Whitewater Rapid

General Description

In this concept, the existing dam is replaced with a low-gradient whitewater rapid that extends across the entire river. The dam crest remains at or near the same height, however instead of being short and having a steep drop, the dam is graded at a flatter (usually less than a 1 percent) slope. Usually implementation of this concept entails a structure that can be hundreds of feet in length. The result is a structure that can appear to be a naturally appearing whitewater rapid. These "rapids" can include non-uniform drops, eddies, waves, and riffles similar to those that occur in natural rivers where many large rocks are introduced into a river, such as at the mouth of a tributary river or where there is a local outcropping of a hard geologic formation. Figure 23 below illustrates a route full river through a low gradient drop or rapid.



Route Full River Through
Low Gradient Drop or "Rapid"

Figure 23 - Natural Whitewater Rapid

Fish Passage

Since this concept simulates natural formations it provides upstream fish passage in a seamless way - the whole river from bank to bank comes into play at the various river stages. At low flow the water is concentrated in the central channel and fish move along the bottom in deep water. At higher stages the banks of the river, with their lower velocities and rough bottom, allow fish migration. This concept is more efficient and lower maintenance than conventional fish ladders since it appeals to a wide range of species over a wide range of flows.

Recreation

Recreational boat passage is identical to natural rivers; it provides a natural rapid through the full range of flows. At low to moderate flow, the rapids may be mild. At high flow, the rapids can become much more powerful or be drowned out by the down-stream tailwater. If hydraulic conditions create a more powerful rapid at higher flows, the structure can be designed to have only moderate increases in technical difficulty for the experienced and properly equipped whitewater boater.

Management

Since this concept is like a natural river and without control of flow, it requires no special management scheme, unless crowding becomes an issue at peak times. If crowding or other issues warrant, a permitting system for all users of the facility may be one solution. Outfitters or canoe liveries providing services on the river are typically required to be licensed by the state for their line of work.

Example

The proposed Farad Dam replacement on the Truckee River, in northern California, utilizes a rapid that stretches across the entire width of the river in lieu of a fifteen-foot crib dam. Most of the rapid is made of boulders, with a smaller portion being made of man-made materials. This was achieved by moving the diversion point further upstream than the original structure in order to take advantage of the naturally-occurring drop in the river.

Figure 24 - Artist's Conception of Farad Dam replacement

Because of the large volume of material required, this is an expensive option on wide rivers such as the Fox. Alternative 1 utilizes this concept in conjunction with a cost saving measure of reducing the channel width by joining Duck Island to the main island to the south.

Concept B ~ Whitewater Bypass Channel

General Description

In this concept the river is partitioned. The dam is replaced across most of the river, however along one bank a whitewater channel passes around the end of the dam. The dam is modified to improve boating safety with a step configuration on the down-stream face. The channel is located next to the shore and separated from the river by a divider wall running its length. The channel slopes at a relatively gentle gradient in order to provide mild whitewater rapids, as well as fish passage. Terraces and overlooks for viewing the facility are on the landward side.

The whitewater channel is hydraulically connected to the river at both the top and bottom. It is essentially a run of the river channel and comprises a part of the river's flood conveyance. Figure 25 below illustrates a route controlled flow through a hydraulically disconnected side channel.

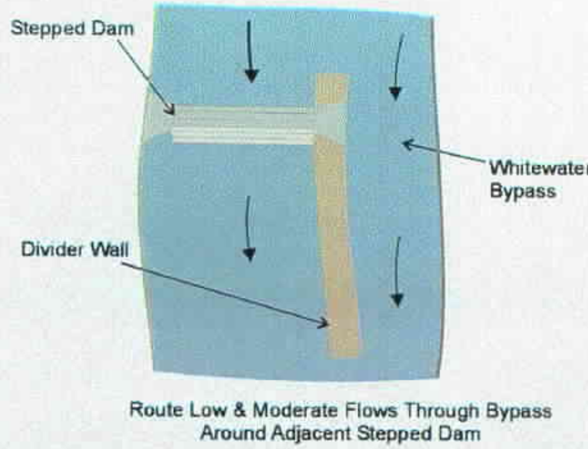


Figure 25 - Whitewater Bypass Channel

Fish Passage

Fish passage in this concept is more efficient than conventional fishways. The man-made channel is roughed to provide slower water and eddies that fish need to make their accent, albeit in a narrower channel than a natural river. For effective fish passage, fish must be attracted to the mouth of the man-made channel - if they miss the entrance they face a dead end at the dam. At low flows most of the water flows through the man-made channel, so this is not a problem. At higher flows when proportionally more water goes over the step dam some dead-ending may occur due to multiple attraction flows. If fish do enter the man-made channel, pools and drops provide methods for resting and ascent along the pathway, however, issues of cover and depth may preclude some species from ascending. Therefore, as in all fish passage structures the physics of water flow in the man-made channel are acceptable for fish passage, but behavior of the fish may not provide for acceptable numbers of fish ascending through this pathway. Therefore during final design phases of the man-made whitewater channel, careful attention must be given to provide appropriate hydraulic characteristics along with good attraction flows, plenty of cover and depth, and a continuous pathway from fish entrance to fish exit.

Recreation

Whitewater recreation is created on the bypass channel. The channel is graded to provide Class II whitewater, with a possibility of Class III at high water. Because of the concentrated rapids, it is likely to become a destination for recreational boaters as well as popular spot for tubing. A full hydraulic connection to the impoundment above the dam and the river below allow a continuos river trip without getting out of the boat. A portage trail however is provided so that persons not desiring to run the rapids will have an option to carry. Because the channel is separate from the main river, it is easier to host whitewater competitive events such as slalom and rodeo. These events can draw large numbers of spectators to the site, if they are properly promoted.

Management

Because the bypass is a run of river, there is not an implied degree of control as with some of the options below. Since a dam is still relied upon to impound water, some hazards with this dam are inherent and maintenance of warning signage and buoys is needed. In addition there may be more maintenance to remove debris than would be found in a natural river.

Example

A good example of this concept is Confluence Park, on the South Platte River, in Denver, Colorado. The context of this project is the 13-mile South Platte River trail system, comprising flat water stretches and several other dams that are breached by boat chutes. The river functions both as a river trail for rafting and as a "whitewater destination"; a spot where boaters come to spend time at a small section of whitewater rapids, but do not venture downstream or upstream. Other than special events, Confluence Park has no formal management for users. Maintenance is provided by several entities including the Urban Drainage and Flood Control District and the Greenway Foundation.

This concept has application at Batavia and is developed as Alternative 2.

Figure 26 - Confluence Park in Denver, CO

Concept C ~ Off-River Channel

General Description

The off-river channel is similar to a dam bypass in that it uses the drop and the water supply from a dam as above, however it is located away from the river in an adjacent land area. The off-river channel usually includes a more restrictive or intricate entrance or headworks structure. This limits flood flows to the off-river channel and can allow the channel to be closed. Unlike the bypass channel, the off-river channel does not usually convey a significant portion of the flood flows. Figure 27 illustrates the route low and moderate flows through a bypass, around an adjacent stepped dam.

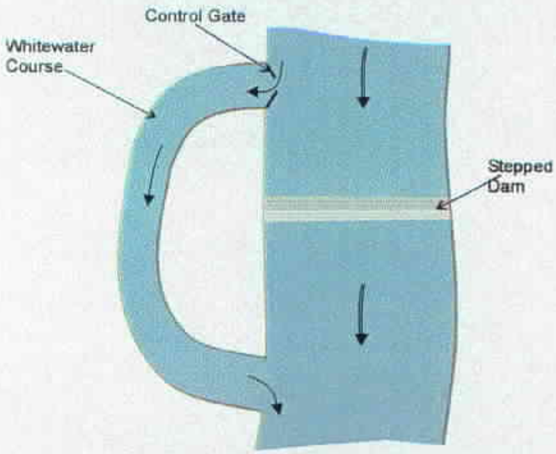


Figure 27 - Off-river Channel

Rather than being a run of the river, most projects of this type have controlled operating flows that can be maintained within a much narrower range than ambient conditions. Because two sides of the channel are accessible and less prone to flooding, visibility of the course is maximized. This greatly enhances the venue for recreation and whitewater competition. Most Olympic whitewater courses are this type.

Fish Passage

This concept is similar to a dam bypass in that fish passage is achieved in a man-made roughened channel that is not part of the main river. An important difference however is that the discharge of the artificial channel is usually a good distance from the dam, creating the likelihood of a dead-end, migration route. To improve fish passage, this type of project usually employs a secondary conventional fish ladder at the dam. In addition, design of the control gate needs special attention in order to pass fish and modulate flow at the same time.

Recreation

This concept has the highest value for whitewater recreation since conditions are the most controlled and since it has the highest visibility for spectators and events.

Management

Since this concept is a completely man-made solution, it implies a measure of control not found in the other concepts, hence it has the highest burden of management and liability. There is also the associated cost of maintaining the water-control, entrance structure and grounds. As described above, a fish passage over the dam is usually required. Maintenance of this structure increases the overall management and operational costs involved with this concept.

Examples

There are numerous examples of off-river channels abroad, notably the venues for the 1972 Olympics in Augsburg, Germany, the 1992 Olympics at Seu d'Urgell, Spain and at Nottingham, England. The most well known off-river channel in the U.S. is located at South Bend, Indiana.

This concept is applied in Alternatives 3 and 5.

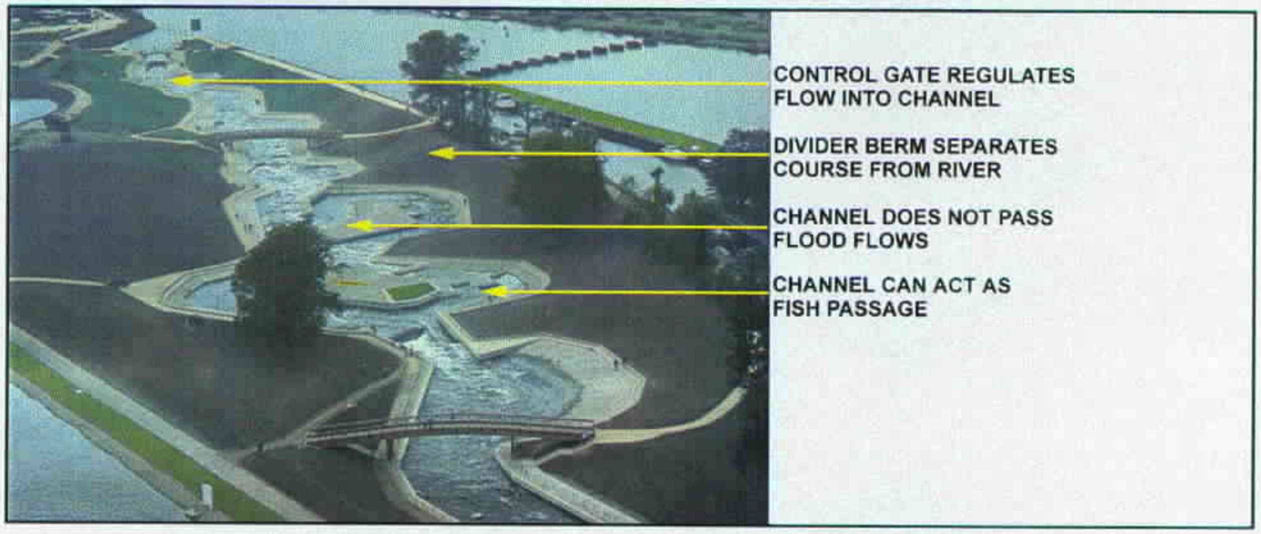


Figure 28 - Off-river Channel at Nottingham, England.

Concept D ~Dam Lowering/Removal

General Description

In Concept D, the Upper Batavia Dam is lowered or almost entirely removed. Dam removal is gaining in popularity, with more than 456 projects (Ref. 31) being removed in the last few years, most notably Edwards Dam on the Kennebec River in Maine. The main benefits of dam removal are improved fish habitat and water quality, although effected shoreline landowners usually have concerns.

Since Depot Pond relies on the existing dam, dam removal alone would drain the Pond and therefore not meet the stated objectives. To maintain the existing Depot Pond, a new impoundment dam would be necessary. Unlike the existing dam, this dam would not cross the river. The new dam would instead isolate the pond from the river, so that the two would be hydraulically disconnected. In other words the water surface in the pond would be elevated above that in the river.

The main benefits of dam removal are environmental. Increased natural riparian habitat and natural fish passage are the positive points.

Fish Passage

Since the river is restored to nearly pre-dam conditions, the most natural and highest quality fish passage is attained.

Recreation

River recreation could be restored to a level provided by the pre-dam channel or enhanced to include riffles and pools. Without the dam or significant whitewater rapids, a seamless river trip is possible in a wide range of human-powered boats.

Management

Since the river is restored to nearly pre-dam conditions no additional management is required for this concept.

Examples

Edwards Dam in Augusta, Maine was recently removed, in an event that received national media coverage. This was the first time a FERC-licensed dam was ordered removed.

This concept is applied to Alternatives 4 and 4a.

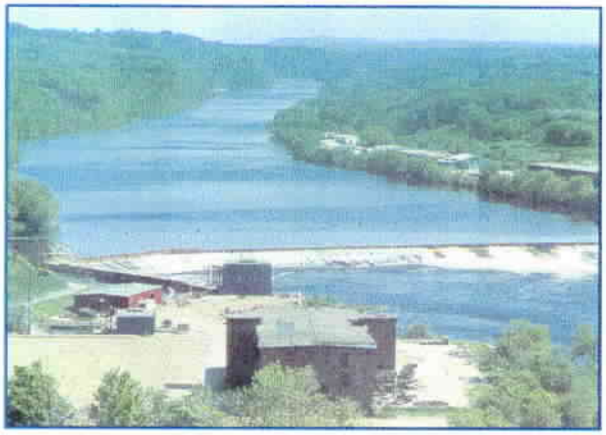


Figure 29a - Edwards Dam on the Kennebec River Prior to Removal.


Figure 29b - Edwards Dam on the Kennebec River After Removal.

DAM REMOVAL

As noted in the Background chapter, the Upper Batavia dam is no longer used to generate hydromechanical power. Its sole purpose is to maintain the two-mile long upstream pool for aesthetic reasons. There has been a trend in recent years toward removing dams that have outlived their original function. Hundreds of obsolete, unsafe, and unused-dams have been removed by communities across the country during the last few decades and scores are slated for removal. In the course of this study the modified dam removal concept presented in the previous chapter was identified.

The following dam removal case studies prepared by American Rivers (Ref. 34) have similarities to the Upper Batavia Dam:

Barbaroo River, Wisconsin, Waterworks Dam

- 9 feet tall and 220 feet long.
- Midwest low, head dam originally built for hydropower.
- Was declared structurally unsound.
- Public opposed dam removal at first: historical concerns, loss of dam impoundment. There were legal challenges.
- Removal was more cost effective than repairs or replacement.
- Enhanced riparian habitat.
- Resident fish passage.
- An earlier rock and timber crib dam was found. Materials were used in shore stabilization.
- Sediment was flushed downstream and may be removed with the removal of a lower dam.
- Cost - $214,000 (1998)

Cannon River, Minnesota, Welch Dam

- 9 feet high and 120 feet long.
- Midwest low, head dam originally built for hydropower.
- Inactive hydropower facility, structurally unsound and a hazard to canoeists.
- Six drownings in 25 years.
- Dam rubble used to stabilize shoreline and fill scour hole in river.
- Citizen concerns over impact of removal but no opposition.
- Enhanced riparian habitat and water quality.
- Passage for resident and anadromous fish.
- Sediment was flushed downstream.
- Cost - $45,000 (1994)

Milwaukee River, Wisconsin, Woolen Mills Dam

- 18 feet high.
- Obsolete low head hydropower dam built in 1870 with later improvements.
- Structurally unsound.
- Landowners opposed to dam removal-loss of scenic qualities of dam impoundment and lower property values for adjoining owners.
- Added recreational land next to river and higher property values for river front owners.
- Improved riparian habitat and water quality.
- Provided resident fish passage and overall improvement of sport fishery.
- Sediment was stabilized in place. Seepage from a nearby landfill was a concern.
- Cost - $86,000 (1988)

Kennebec River, Maine, Edwards Dam

- Was the first ordering of a dam removal by the Federal Energy Regulatory Commission.
- 917 feet long by 24 feet tall.
- Dam owner and adjacent landowners were opposed to removal.
- Restored 17 miles anadromous fish habitat and provided passage.
- Created mild rapids and opportunities for recreation on the river.
- Very little sediment, banks were armored with deconstructed dam material.

Willow River, Wisconsin, Mounds Dam and Willow Falls Dam

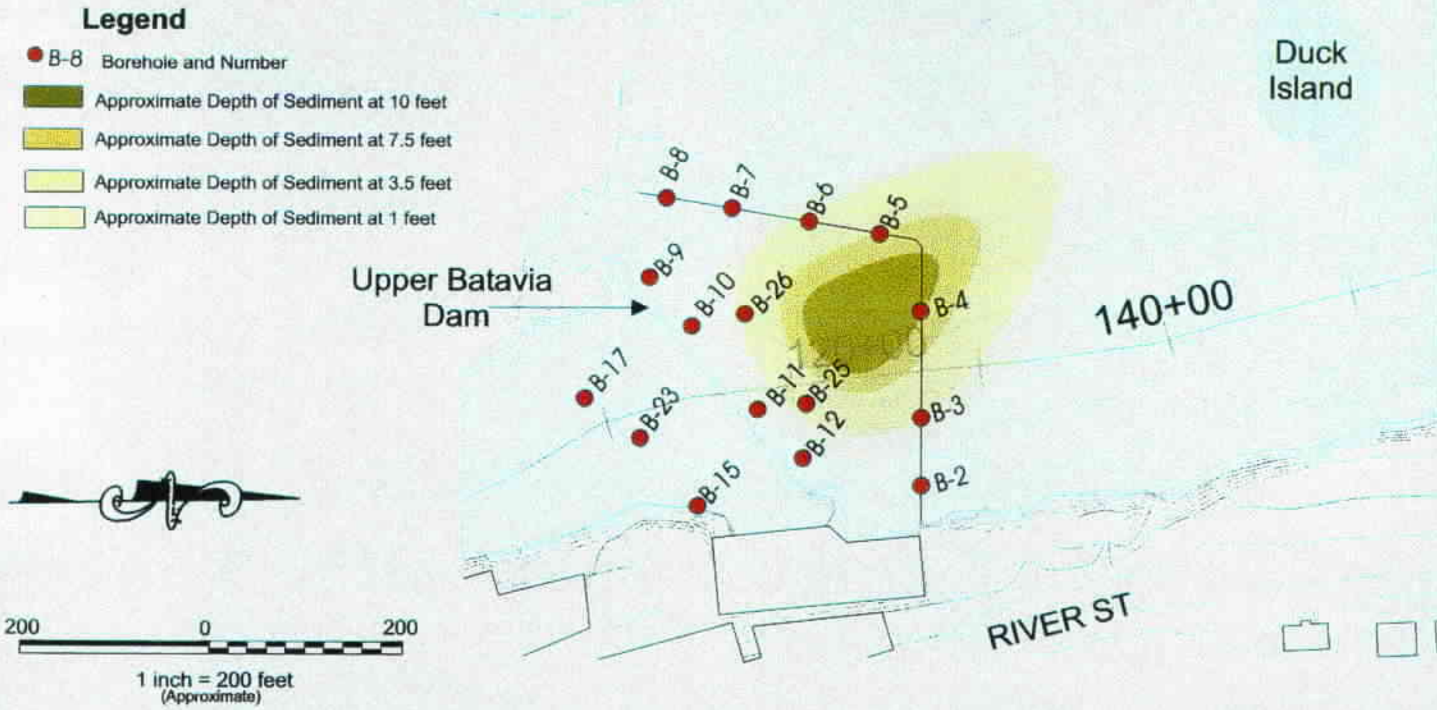
- Sediment was stabilized in place. Seepage from a nearby landfill was a concern.
- High head (60'+/-) hydropower dams on a relatively high gradient river.
- Structurally unsound and very expensive to repair.
- Overwhelming public support for keeping the old dams.
- Restored river included scenic limestone canyon.
- Scenic and recreational asset near major metropolitan area.
- Improved riparian habitat, water quality and recreational fishery.
- Some sediment was stabilized in place and some was released down stream. Released sediment may have to be dredged from an impoundment.
- Cost - $170,000 (1998); $420,000 (1992)

SEDIMENT

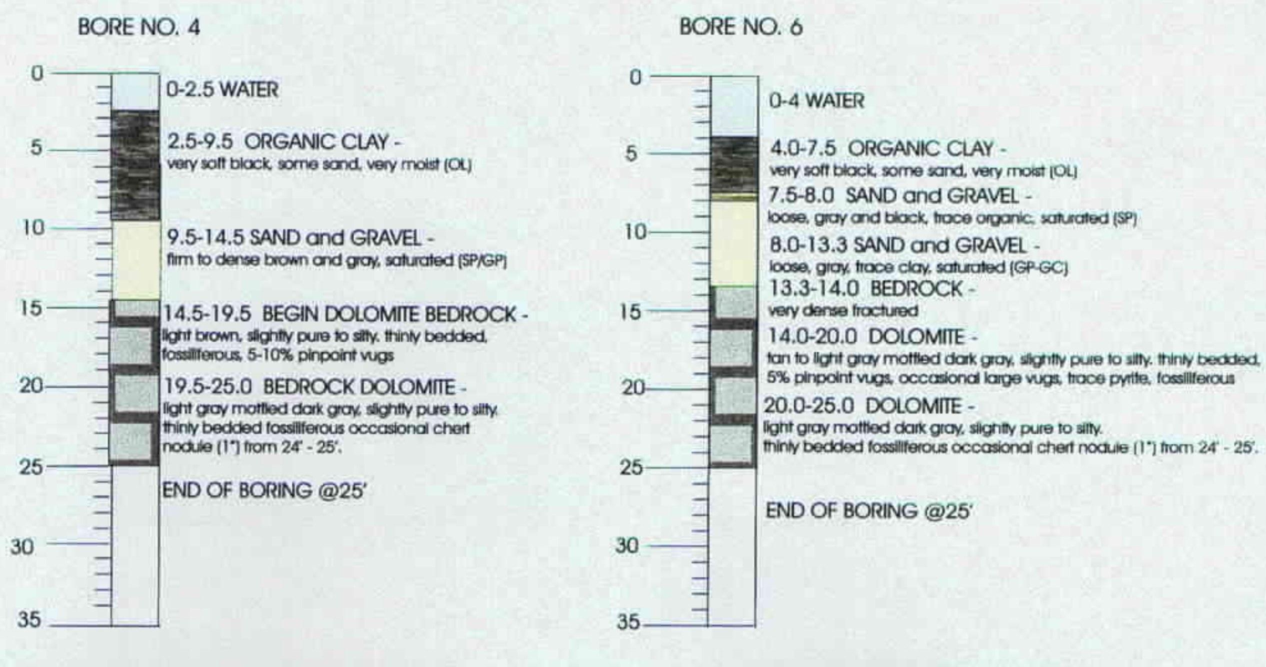
As the water from the Fox River travels downstream, it carries hundreds of tons of particles of silt, sand and clay on a daily basis. The water slows down as it approaches the dam and a portion of this sediment drops out. This sediment builds up over time and eventually reaches a (dynamic) equilibrium. In looking at dam removal, it is necessary to evaluate the quality and quantity of this
sediment upstream of the dam.

One limitation of this current study is the lack of geotechnical information in this upstream reach. Sediment samples and extensive bedrock elevation data have been obtained by IDNR in the immediate reach of the dam, however very little information is known upstream. A Report of Soils Exploration was prepared for the IDNR in December 1998 (Ref. 35). The result of this study is mapping of both the surface contours and the underlying bedrock in the region of the dam. This information however does not cover the entire impoundment. Figure 30 represents contours of the very fine-grained and organic sediment " muck". A total of 17 soil borings were drilled. Results of the borings include the depth of water, depth and type of sediment and depth to bedrock. The results of each boring are summarized in Appendix C. The location of the boreholes along with estimated contours of the very fine sand and muck are shown in Figure 30.

Topographic mapping is available in the upstream reach but there is little subsurface information. The topography was generated from a bathymetric survey conducted by IDNR in June of 2000. The Max McGraw Wildlife Foundation is currently conducting a study regarding fish on the Fox River. In this effort, the top of sediment to the bedrock surface was probed in several locations. The only other data is from the borings for the Fabian Parkway bridge crossing. Neither of these studies however cover the entire impoundment or consider sediment type and composition.



TYPICAL BORE HOLE RESULTS



McLaughlin Water Engineers, Ltd.	ILLINOIS DEPARTMENT OF NATURAL RESOURCES	SOILS BORING RESULTS JUST UPSTREAM OF DAM	DESIGN: JMC DETAIL: KMG,ARB CHECK: REM DECEMBER 2000	Figure 30

s:\dwgs\99\99-041\001\corel\borehole2

Estimate of Sediment Behind The Upper Batavia Dam

Based upon this limited data, a gross estimate of sediment within the impoundment is 270,000 cubic yards. This estimate is approximate and should be refined with further geotechnical investigations if a dam removal alternative is selected. The methodology of the approximations is described below.

Figure 31 represents the accumulated sediment volume as determined by The Max McGraw Wildlife Foundation. The study area begins just upstream of the dam at approximately station 119+50 and extends to approximately station 132+00. It does not account for any sediment located in Depot Pond. This study included 38 probe locations that were reportedly taken to bedrock. The information includes all smaller grained sediment in the area sampled. The type or specific composition of the sediment has not been determined. It should be noted that this study is in the preliminary stage and all data and results are not necessarily final or complete. The total volume of sediment in this area is estimated at 89,000 cubic yards. The northern boundary of this reach has an estimated depth of sediment ranging from 1.5 to 3.5 feet.

There is an estimated 88,000 cubic yards of sediment in the reach between station 132+00 and the Fabian Parkway (station 156+00). This was determined by using the average sediment area between cross-sections at these two stations. The quantity of sediment upstream of station 156+00 was extrapolated from downstream data using computer-generated profiles. Based on these profiles, it was assumed that there is little impounded sediment above station 220+00. This volume is estimated at approximately 93,000 cubic yards.

Sediment and Fish Habitat

Sediment composition is important for aquatic species because the bottom type that they associate with governs so much of their life history. The water velocity dictates the resultant bottom sediment size. Certain species associate their food forage with aquatic benthic organisms that live in gravel and cobbles. Others associate with grasses and structure such as wood or large rocks. Each bottom type and water velocity attracts specific species.

When the reservoirs above the dam silt in with sediment, the species of fish associated with gravel, cobbles or large structure do not exist. Only species associated with silt bottoms exist because their forage and life history is supported there. Another aspect of sediment being detrimental to the aquatic habitat and fish species is from turbidity and settlement of sediment on to the bottom. Environmentally detrimental consequences would be created if sediment that now exists in the pool above the dam were allowed to mobilize downstream. Resulting turbidity would cause irritation to fish gills, settlement onto spawning and nest building gravels, loss of benthic organisms for food, and fill pools downstream of the project such as the next dam downstream. This is a detrimental condition because of the lack of diversity of aquatic species present throughout the Fox River. As shown in the Max McGraw study, the reach immediately downstream has shown improvement and release of sediment would harm this improved habitat zone.

An opportunity exists to restore the area above the dam, where sediment has been deposited for many years, to provide water velocities that will maintain gravel and cobble bottom types. Some or all of the existing sediments can be stabilized into over bank areas. Areas of overbank can be planted with grasses for forage and nesting during

Interpolation: IDW, Power-2, Neighbor-8, cell size-1m
Coordinate System and Datum: UTM NAD83, zone 16.

Produced by: Mari Nord
October 30, 2000

high river stage seasons. These areas will act as very fertile benches and offer a great benefit to the restoration efforts of the riparian margins of the river. Wood or rock in-stream habitat structures should be restored that are stable, and will attract a greater number of species of fish associated with structure and its resultant water velocities. These efforts should be included in any restoration effort considered for partial or complete dam removal options.

<u>Sediment Handling</u>

Sediment is a key subject of dam removal since there is such a substantial amount of sediment located above the dam and costs related to sediment removal or stabilization are appreciable. Some issues to consider in dealing with dam sediment include:

- Volume of sediment
- Nature of sediment build-up
- Presence of toxins e.g. PCB, heavy metals, pesticides, etc.
- Presence of excessive nutrients and fertilizer residue
- Particle size
- Slope stability of material combined with gradient and hydrology of channel
- Presence of downstream dams and impact on other projects (Lower Batavia, etc.)
- Tolerance of aquatic species to sediment
- Natural base sediment load

At this time only an estimate of volume has been made to characterize the sediment in the entire upstream pool. Therefore only general approaches can be discussed at this time. Options include releasing the sediment downstream, removal, stabilizing in-place, with the final plan possibly being some combination of these options. All of these options have broad implications and careful consideration needs to be taken on which method is best for this site. These general options are discussed in further detail below, but if a dam removal option is selected, further data is necessary to determine the approach or combination of approaches.

Downstream Sediment Release

The least expensive option is to release the sediment downstream. This can be accomplished on some type of extended release schedule. Literature on sediment releases related to dam removals is scarce. Because of the relative economy with this method, agencies and organizations promoting removals have focused on the benefits of removal and have been inclined to accept the consequences as a cost of environmental progress. However, there are detrimental impacts on habitat as described above. If toxins are found to be present sediment release could pose a further health threat to both aquatic habitat and humans. Some issues to consider if looking at releasing the sediment downstream include:

- Volume of sediment
- Type of sediment (fine grained sands, clays, muck, etc.)
- Quality of sediment (Presence of toxins e.g. PCB, heavy metals, pesticides, etc)
- Time of year for release i.e. interference with spawning
- Recover time
- Cumulative effect on environment, infrastructure
- Downstream constraints

As noted in the previous section, there is a substantial amount of sediment upstream of the dam. Because of the detrimental environmental impacts, it is our opinion that release of a substantial proportion of the impounded sediment is not a good solution at this site. The decision to release sediment should also be made on a policy basis. That is the decision to accept downstream detrimental effects at this site may set a president for other projects in this region.

Sediment Removal and Disposal
Removing sediment is the most expensive option. There have been a few dam removal projects and many other river related projects where large amounts of sediment was dredged and removed. Note that sediment from Depot Pond was previously disposed of using this method. The cost issue is finding a disposal site and the distance to haul it. This option may be appropriate for a portion of the impounded sediments if found to contain toxins or substances particularly harmful to the aquatic habitat. This option may also be implemented if the total volume of sediments can not be practicably stabilized in place as discussed below.

In-place Sediment Stabilization
In many cases major proportions of the impounded sediment are stabilized in place. This is usually the least cost and most environmentally beneficial solution when wholesale release is not a realistic option. Subsequent cost estimating at this site confirmed this conclusion. The sediment can be stabilized to form islands and overbank or floodplain areas. This maintains the overall width of the river similar to existing conditions, but constrains low flows to a narrower channel. The resulting environmental and aquatic habitat benefits are outlined in a later section.

Because of the proximity of the Upper Batavia Dam, the appreciable volume of sediment, excessive cost of removal, and negative environmental impact with sediment release, in-place stabilization of the sediment is recommended as the most appropriate option. As noted previously, a more detailed analysis of the volume and quality of sediment will be necessary. Given the available information, the majority of the sediment can be stabilized in-place. However, depending on the quantity, quality, and composition of the sediment, some sediment may need to be removed and disposed of. The costs estimates located in a later section have included in-place stabilization with modest amounts of sediment removal.

Sediment in Depot Pond
Another sediment related issue is sediment deposition in Depot Pond. Depot Pond continually fills with sediment as a result of river dynamics. Flow and sediment enter the pond due to lower velocities within this area, the sediment settles out and water exits this dead-end channel, leaving some of the sediment behind. If left alone, this natural process would cause this dead-end channel (Depot Pond) to completely fill in and become some form of dry or wetland area. A few years ago, the City of Batavia had the pond dredged to increase the depth of the pond. Approximately 31,000 cubic yards of sediment was removed from the pond; the cost of removal was approximately $400,000. It is reported that recent sedimentation has caused the pond to fill in again to about the level prior to the sediment removal operation.

PROJECT ALTERNATIVES

All of the alternatives presented in this chapter fall within the definition of a multi-purpose dam; each provides both recreational and environmental benefits. The alternatives impound water yet provide for both fish passage and recreational boat passage. The alternatives were developed from the general concepts presented above to incorporate the project objectives.

Drawings of each of the alternatives presented below are included in this report. Drawings 4 through 10 show a plan and profile of each alternative. Alternatives 1, 2, 3, and 5 maintain the pre-breach upstream pool elevation in the upstream river channel. Alternatives 4 and 4a lower the dam crest and the upstream water surface to varying degrees. Both of these alternatives also include a new impoundment dam to maintain or slightly increase the water surface elevation in Depot Pond.

Alternative 1 ~ Full-Width Whitewater Rapid

<u>Description</u>

Alternative 1 includes replacement of the existing dam with a full-width river rapid, as illustrated on Drawing 4. The alternative incorporates boat and fish passage into a single roughened channel with an approximate hydraulic grade of 0.65%. The upstream pool elevation of 664.7 feet is maintained. The crest of the dam is located approximately 900 feet upstream of the current location. The existing pool, located just downstream of the existing dam, will serve to dissipate residual energy and velocity from the rapid.

The rapid is located entirely upstream of the existing dam, due to constraints of the floodplain. The elevation of the retirement home and property dictates that there can be no local increase in the flood elevation downstream of the existing dam. The length of the rapid is based upon the selected design gradient of the rapid. Determination of the gradient was based upon the recreational goal of creating a Class II to Class III rapid and design fish passage velocities and flow characteristics, tempered by cost considerations. Economically, a steeper and shorter rapid is advantageous, however meeting the boating and fish passage goals becomes more difficult with increasing slope.

The following sections on fish passage and recreation elaborate on the choice of the selected design slope or gradient of the rapid.

The west side of the rapid entrance or inlet weir abuts to the bedrock outcropping that forms Duck Island. This is one of three rigid control structures or weirs that span the entire width of the river and form the backbone of the man-made rapid. These structures are designed to survive and hydraulically operate without any other materials or structures in the river channel. The east side of the weirs abut to the existing riverbank. An earthen berm is constructed from the south side of Duck Island to the north side of the peninsula. This earthen berm impounds water within Depot Pond and serves as the river right abutment of the structures that form the rapid. The face of the berm that forms the channel is armored to protect against flows up to the 100-year event. Various man-made rigid and mobile structures are built between the weirs and create flow patterns such as riffles, pools, and eddies. These benefit fish passage and habitat, and enhance recreational boating. The mobile structures or armoring will include loose rock,

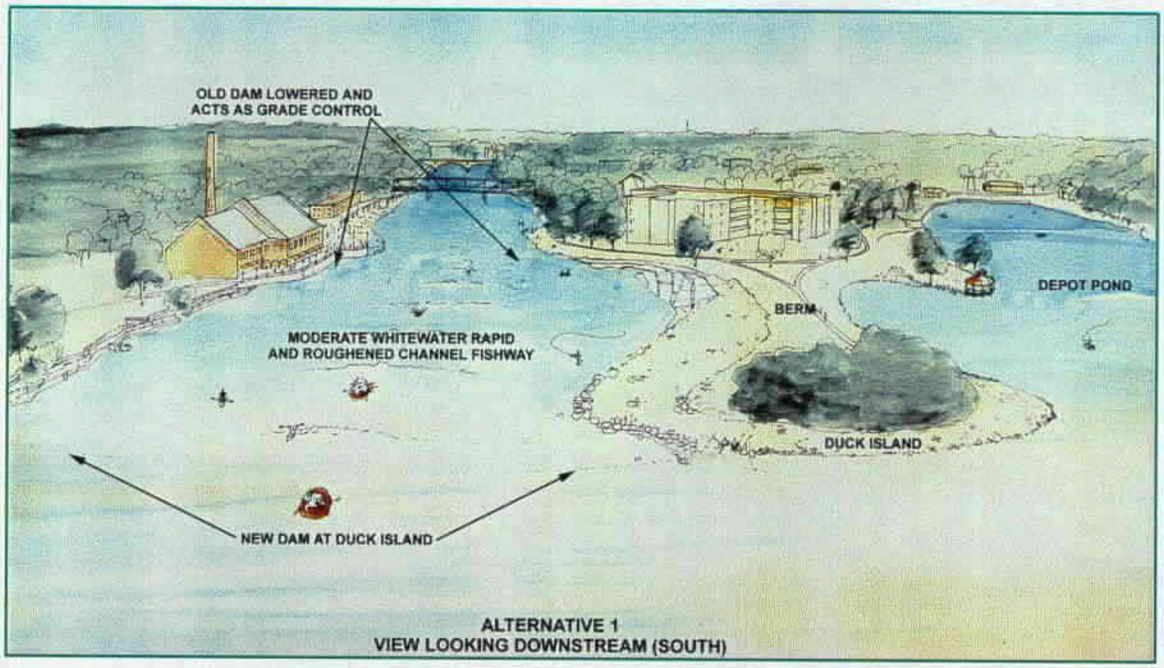


Figure 32 - Artist's Rendering of Alternative 1

river cobble, and vegetated earthen banks.

The existing dam is cut down to form the most downstream of the weirs described above. The failed portion of the dam is repaired, and the weir is abutted to the east river bank upstream of the Challenge Building, via a concrete wall.

Fish Passage

Fish passage is accomplished in a natural roughened channel with a hydraulic gradient of 0.65 percent. This is fairly mild when compared to 5.5% for roughened channels in the Northwest. The low flow channel in the center of the passage concentrates water and provides adequate water depth for bottom swimmers. Sloping sides (ranging from 2:1 to 5:1) provide variable water depth to accommodate a wide range of fish behavior over a wide range of discharge. Velocity is variable due to roughness elements along the sloping sides. Small eddies behind these rocks provide resting spots in a random field that also includes faster jets of water. At higher stages the principal is the same, the "comfort zone" of velocity and depth for the various species just moves further up the bank.

The weir and counter weirs will have fixed roughness elements in order to avoid the negative effects that are typical with smooth, broad crested weirs. These will be either of grouted rock or carved concrete "faux rock" elements. Between the three control weirs (described above) the roughness elements are ungrouted rock. Post construction monitoring will be needed to insure that no area is being scoured or depleted of roughness elements to the detriment of fish passage. In natural rivers, scour areas could be replenished by additional material moving downstream. At this site however recruitment of additional bed load is unlikely due to both the length of the impoundment and presumed general lack of bed load due to the large number of dams in the upstream river reach. Therefore it may be advisable to "seed" the rapid with additional cobbles and fines if conditions such as sharp plunging flows appear. Persistent problem areas may need to be treated with grouted rock.

This alternative has very positive aspects for fish passage. The fish entrance to the passage area (the main channel of the river) is located at the centerline of the river, similar to any other roughened channel. The fish exit is acceptable and is also centered at the river thalweg. All target species of fish would pass over this configuration of a multi-purpose dam. Fish passage pathways exist at the thalweg during low flow and during high flow conditions. Interstitial spaces between the rocks and eddies behind the rocks provide a high flow pathway for fish passage higher up the banks. The potential for fouling from debris is low for this alternative.

At one time it was discussed that interest for public observation of fish migrating or moving upstream might be a goal. This alternative provides a poor opportunity for public observation of fish migration. Due to the flat slope required to meet criteria, the length of the roughened channel is long. This can cause delay and or fallback for certain fish species that do not have a strong behavior to ascend over the project.

Careful attention must be given to the fish pathway at the modified check dams so that during low flow conditions water velocities are acceptable for all target species to pass. The fish passage pathway must be continuous across these check dams. Precautions will need to be taken so that interference does not occur with fish resting areas and the configuration of whitewater flow areas and shape.

<u>Recreation</u>

Whitewater Recreation - Canoe/Kayak

- There is a significant improvement over existing conditions. The potential danger of the low-head dam is eliminated, and the river opens to continuos trips without the need to portage around the dam.
- The option to portage is provided for river users not wanting to challenge the rapids. The rapids have a Class II difficulty at low to moderate water levels, and Class III difficulty including characteristics such as high standing waves at high water.

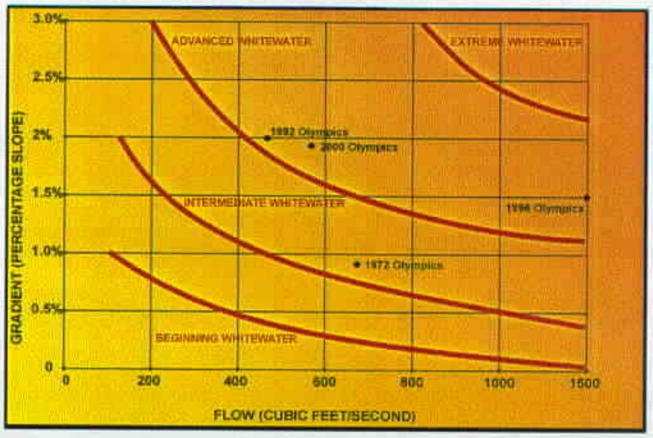


Figure 33 - Comparison of Difficulty and Gradient for Various River and Man-made Whitewater Courses.

- Due to the scarcity of whitewater in the area, the site could become a whitewater destination. This results in increased traffic and demand for parking at Laurel Wood Park.
- Parking at other areas close to the river such as the City office's lot adjacent to Depot Pond could see increased pressure, especially after work on weekdays and on weekends.

Competitive Boating Events

- Marathon Races - the need to portage around the dam is eliminated for most flow rates, though a portage trail is provided for those not willing to negotiate the rapid.
- Slalom Race - an easy race is possible. This includes regional trials, sponsored prize races (Eddie

Bauer) or similar events. The water is not difficult enough, however, for a World Cup race or team trials.

- Whitewater Rodeo - this event is not likely since a variable configuration rodeo feature cannot be installed and maintained in a natural river environment.

Open Deck Canoe

At low or moderate water, the rapids are near the limit of navigation for users without moving water experience. At high flow it would likely result in an upset. A portage trail and warning signs are provided for these types of flows.

Power Boating

Power boating on the dam impoundment is not appreciably effected. One change is that the impoundment is reduced by approximately one acre, by the creation of the man-made rapids.

Recreation on Depot Pond

Recreation on Depot Pond is not appreciably affected by the project. However, one change is a causeway out to Duck Island, effectively enlarging the pond. This is difficult to predict; changes in sedimentation rates for the pond may result from the construction of the berm. This maintenance issue would be better evaluated in the final design phase.

Land-based Recreation

The walking trail on the causeway to Duck Island will extend the foot trail by about 1200 feet. A bridge from Duck Island to the east side of the river may be added by the city if desired. However, there are concerns about introducing bike traffic into the trail system at Depot Pond, which is intended for foot traffic. A bike trail connection through the Challenge Mill property is also possible. As this property is redeveloped, it is likely that pedestrian traffic will increase. Therefore as this concept is refined, a separation of high speed bike traffic and pedestrian routes will be considered.

The whitewater rapid will attract boaters who will park at Laurel Wood Park. This may result in crowding during peak times, especially after work and on weekends.

Alternative 2 ~ River-Right Whitewater Bypass

Description

Alternative 2 includes a stepped dam in the same location as the existing dam with a whitewater bypass around the west abutment. As shown on Drawing 5, the whitewater bypass or boat chute begins on the northwest side of the peninsula in Depot Pond and wraps around the peninsula. The course ends at the dam. The existing dam will be replaced with a step dam. It is angled so that flows may be directed away from the east bank of the river toward the center of the channel. The upstream pool elevation is maintained. The east side of the dam may abut downstream or upstream of the Challenge complex via an extension wall.

This alternative is similar to one presented in the earlier 1978 report, however Alternative 2 is much longer and has a flatter gradient to attain the desired level of difficulty as discussed above.

This alternative was rejected during the preliminary evaluation process. A hydraulic profile was not developed since it was dropped from further consideration. This was a decision made by the design team, IDNR, and The City of Batavia staff. It was not considered viable for several reasons, but primary concerns included:

- It places high recreation traffic adjacent to the retirement community.

- It requires a levee or berm around the retirement home to mitigate flood impacts.
- It causes negative impacts to the community-constructed river walk.

Fish Passage

Since this alternative has been dropped from further consideration, fish passage and habitat impacts are not presented.

Recreation

Since this alternative has been dropped from further consideration, a detailed recreation evaluation was not completed.

Alternative 3 ~ Whitewater Course Through The Cut

Description

This alternative is a refinement of the off-river whitewater course concept and is located through the Cut. The course begins in Depot Pond and continues through the Cut as shown on Drawing 6. The course has a minimum length of 900 feet. The Cut is widened in order to accommodate the course and adjacent area needed for maintenance, access and viewing. The existing roadway, bridge to the retirement home, and pathways are replaced and relocated as necessary, but parking is lost in the city's lot south of the Cut. The upstream portion of the course is separated from Depot Pond by a divider wall. This structure is designed to withstand the difference in water surface between the pond and the lower water surface in the whitewater course. An intake structure would control the flow of water diverted to the course. This allows the course to be closed for maintenance, such as debris removal, and to adjust the level of difficulty in the course.

A roughened channel type fish passage is incorporated into the banks of the whitewater course. The course ends approximately 1000 feet downstream of the replaced dam. This produces the need for a formal fish ladder structure (located on the face of the stepped dam) to accommodate fish that do not find the outlet of the off-channel whitewater bypass. Another ramification of having the whitewater channel outlet downstream of the dam is that the 1000 foot section of river between the dam and course outlet may be nearly dry or stagnant during low-flow periods.

The existing dam is replaced with a step dam located near the current location. The east side abuts either downstream or upstream of the Challenge Building via a concrete extension wall.

An alternative similar to this was also identified in the Wright-McLaughlin report prepared in 1979. The proposed length of Alternative 3 is longer than that originally proposed, and is extended upstream into Depot Pond and downstream below the current outlet of the Cut. As shown on Drawing Number 6, the upstream portion of the course within Depot Pond is oriented southward with an option of a northward extension. If this alternative is selected, further design and input from the city are needed to determine the location of the upstream portion of the course. Due to the complex flow and confined site, physical modeling of the off-channel whitewater course is necessary during the final design phase.

Fish Passage

In this concept there is a whitewater bypass channel with its outflow approximately 1000 feet below the replaced dam. At low flow the dominant current and therefore the strongest attraction will be at the outflow. At higher flows, however, the dominant attraction flow will be to the main river channel which dead ends at the dam. Therefore the bypass channel will need to be supplemented with a conventional vertical slot fishway at the dam. Drawing 6 shows the fishway on the east dam abutment. This location though logical is problematic:

- The likelihood of debris lodging in the facility will increase maintenance burden.
- A fishway contained within a dam abutment is structurally complicated and flows will be "taken" from the whitewater course.

The concept of bypass channel as fishway was implemented at South Bend, Indiana at the East Race Waterway. At that site, a smooth concrete trapezoidal channel was fitted with movable obstacles of wood and fiberglass. It provides both kayaking as well as passage for salmonids. It also has a supplemental fishway at the face of its dam for the reasons discussed above.

The channel needs to have a large number of roughness elements to keep velocities low in order to pass the slower swimming fish. The construction is similar to Alternative 1—grouted hard points with ungrouted rock infill. Because of the relative narrowness of the channel and the emphasis on whitewater recreation, the water will have a much different character than Alternative 1. It will have stronger central current and more sharply defined eddy lines or shears. The flow will also be controlled to a much narrower range. Because of narrowness relative to the flow (500 cfs) and the need for side eddies and powerful currents to satisfy recreation, care must be taken to avoid constrictions that produce velocities that are impassable to most fish. Symmetrically opposed or dendriform arrangement of obstacles should be avoided. Alternating or ladder-form obstacles are preferable.

In addition the water control mechanism (possibly a rubber dam) at the entrance to the boat/fish passage needs to be as transparent as possible to fish passage. Plunging flows over the dam are unacceptable. The inlet works therefore should be designed to restrict water flow to the specified range while allowing for effective fish passage. The dam should only be fully deployed in extreme high water or for maintenance when fish passage is not the primary concern.

The overall slope of this alternative is acceptable for fish passage given the roughness elements providing eddies, plunging flow, and resting pools. Depth criteria are also met in this arrangement. Debris traveling down the whitewater channel is not anticipated to cause fouling problems. There is an opportunity for public observation of migration of fish that may be visible in the whitewater channel.

It is our opinion that the pike species and weaker swimmers of fish may have difficulty passing above the project in this alternative. The most apparent reason for this is the higher velocities associated with the more constrained roughened channel and the lack of cover provided by depth. Behaviorally this will be a more difficult fish passage pathway than the large main channel roughened channel of Alternative 1. All other target species of fish will have little difficulty passing.

We have not attempted to quantify the effect of large numbers of recreational boaters on the behavior of fish attempting to ascend rapids.

Recreation

Whitewater Recreation - Canoe/Kayak

There is a very positive impact to whitewater recreation since the whitewater channel is in a controlled setting and not in the main river channel. This allows the designers more freedom to include special whitewater features that boaters enjoy, such as eddies, waves, and surfing holes. Given this, the site will become a popular destination for whitewater boaters, especially after work and on weekends.

Competitive Events
This concept is very conducive to special events including slalom and whitewater rodeo. Water flows can be adjusted so that difficulty can be raised or lowered to suit the needs of the day.

Since it is not in the main river channel, it is possible to include special adjustable rodeo features and other permanent improvements needed to host events (e.g., a slalom gate system). These features are well-used by recreational boaters as well. Viewing and staging of events are on the adjacent banks and parking lots. There is no change to the canoe marathon event, except a sanctioned portage trail on river right is provided.

Open Deck Canoe
This alternative does not provide passage for this type of craft. A portage trail is provided. Use of the dam impoundment and river below the course outlet is unaffected.

Power Boating
There are no appreciable changes from existing conditions.

Recreation on Depot Pond
Depot Pond is reduced in size, reducing the surface area of the pond available to the various activities there. The potential popularity of the whitewater course could increase foot traffic and competition for parking spaces in the adjacent lots. Warning buoys at the entrance to the whitewater channel are included in this alternative. A positive point is that a strong current into the channel may help reduce sediment accumulation in the pond and related dredging. This effect is greater if the southern alignment of the upstream portion of the whitewater channel is selected during final design.

Land-based Recreation
Allowance for a bike trail connection through the Challenge Mill property can be included in the design of the river left or east abutment. As this property is redeveloped it is likely that pedestrian traffic will increase. Therefore, if this concept is refined, a separation of high speed bike traffic and pedestrian routes should be considered.

The whitewater rapid will attract boaters who would want to park near the course at the city lot, adjacent to Depot Pond. This may result in crowding during peak times, especially after work and on weekends. This could be somewhat averted by directing boaters to park in the Laurel Wood parking area. The boaters could then paddle to and from the whitewater course during peak hours.

Alternative 4 ~ Small Whitewater Rapid with Depot Pond
<u>Description</u>
This is a low gradient river rapid, which spans the entire width of the river. As with Alternative 1, it: 1) combines the boat and roughened channel fish passage into a single design element, 2) has a hydraulic gradient of approximately 0.65 percent, 3) has a Class II to III level of difficulty, and 4) is constructed with rigid weirs interspersed with loose rock, vegetated banks, and various channel features.

As shown on Drawing Number 7, the crest is located approximately 400 feet upstream of the existing dam location. The rapid is approximately 500 feet in length. The existing dam is lowered and modified to serve as the most downstream weir structure. The pool located just downstream of the existing dam serves as an energy dissipater and boater recovery pool.

Due to its reduced length, Alternative 4 only has two intermediate weirs, rather than the three included in Alternative 1. The west side of the upper weir abuts into Duck Island. The east side of this entrance weir partially abuts to bedrock at the east river bank. Similar to the berm in Alternative 1, an earthen berm runs from the south side of Duck Island to the northern tip of the peninsula. An additional earthen berm extends from Duck Island to the east river bank. These berms impound the water within Depot Pond and convert it to an actual pond rather than a dead-end finger of a river bifurcation. The result of this is the elimination of the high sediment load that is currently transported to Depot Pond by the river. The water surface elevation in Depot Pond could remain at an elevation of 665 feet or slightly higher, even during low river flows. A pump (powered by an electric motor and possibly a windmill) or ditch is planned to replace water lost from the pond due to leakage or evaporation. A spillway is located at the Cut to convey local runoff that is currently tributary to the pond. If this alternative is selected, redirection of local inflow around the pond and into the river would be investigated as a means to improve water quality in Depot Pond.

Upstream Restoration Efforts

Alternatives 4 and 4a, as presented in the following section, include rehabilitation efforts to the channel upstream of the lowered dam crest. In Alternative 4, the upstream pool elevation is lowered by about four feet. The water surface area from the existing dam upstream to the Causeway will be decreased during typical summer flows from approximately 60 acres to 40 acres. With a lower water

surface elevation, portions of the channel bottom are exposed and much of the shoreline is covered with a wide and unstable zone of mud. After years, this "mud flat" washes downstream, or stabilizes and develops into floodplain overbank, as illustrated in Figure 25. However, this process leaves the area in an undesirable condition for this interim period. When the dam is lowered, sediment is released. This may have negative impacts on the river ecology fish habitat.

Figure 34 - Milwaukee River, Wisconsin, Woolen Mills Dam Removal

As discussed in the previous section, sediment is considered a pollutant and its release into the riverine environment has become a focus of various federal agencies. Effects on aquatic habitat are outlined below. For these reasons, Alternative 4 and to a greater extent, Alternative 4a, include creation of an overbank area using existing sediments in the river. To aid in this effort, structural stabilization features (further described under Alternative 4a) and plantings and seeding in the overbank or "bio-stabilization" are included, as shown on Figure 26.

It is anticipated that some sediments will be removed entirely from the channel including those in Depot Pond and in the backwater

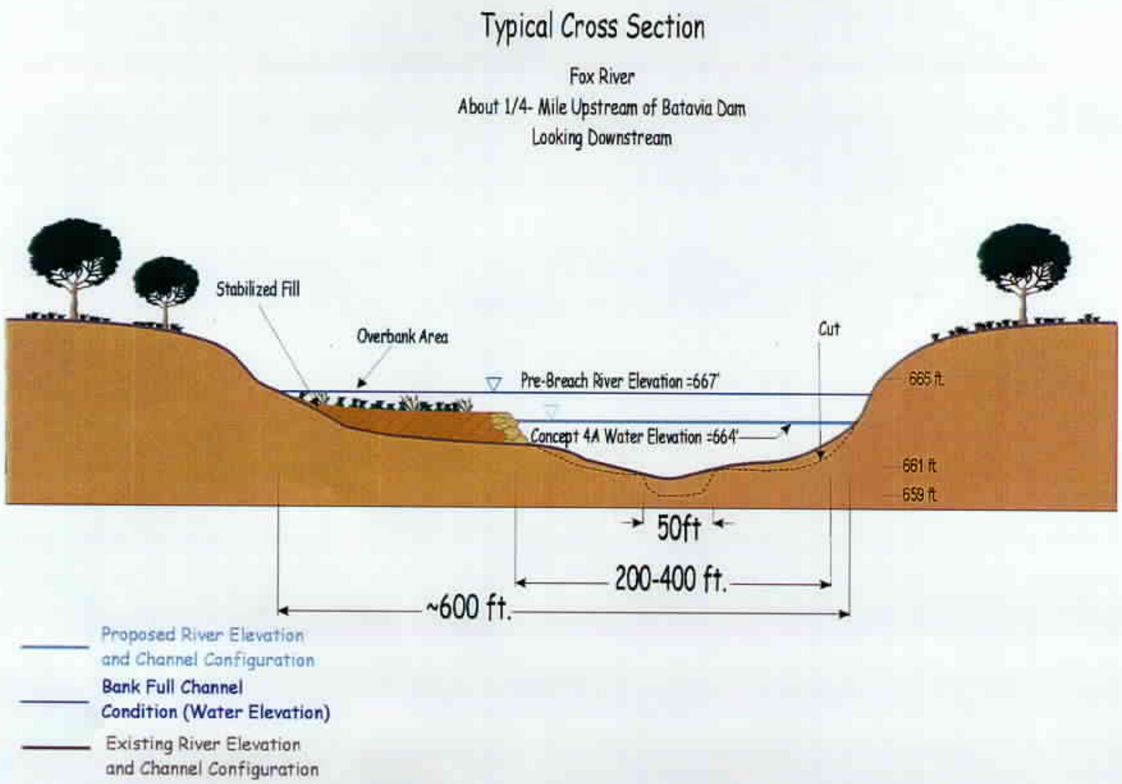


Figure 35 - Cross-section of a Channel Showing the Hydrologic or Bankfull Floodplain and the Entire Floodplain.

area created by the Causeway. Some may also be removed from the active channel, however it is anticipated that most sediments currently in the active channel would remain in place or be used to create new overbank floodplain area. Stabilization techniques to create the overbanks include toe protection and impervious jetties as described in the following section.

Fish Passage

This solution is identical to Alternative 1 only with less drop and length. Since the critical design elements, 0.65 percent hydraulic slope and construction method are the same, the commentary on Alternative 1 applies also to 4 and needs no supplement here. One difference however is that this alternative creates approximately ½ mile of free flowing river and restored riparian habitat in the upstream reach.

The key advantage to this alternative for fish passage is the natural riverbed is created that allows any fish to migrate that would migrate through a reach of the Fox River of similar characteristics. This alternative has the other advantage of allowing habitat restoration elements to be constructed throughout the restored channel and any areas above the upper grade control. All target species of fish will pass across the project in Alternative 4. The potential for fouling from debris is low. The goal of interstitial flow in and around and through rock is perfected. This alternative maintains the river thalweg and provides appropriate resting pools for fish and provides fish passage during all flow ranges for all target species. The issues of fish travel time are minimized because this section of river is restored to typical river morphology of the Fox River.

An excellent opportunity exists in this alternative and others to provide target species with particular restored habitat that is essential for their life history. One example is that the pike species prefer broad flats of tall grassy vegetation for nesting. This could be accomplished by providing sediment stabilization and planting of grass species appropriate for the locale using Coir fabric mats or cellular stabilization geogrids. The coir fabric provides resistance to erosion and establishes early growth of the plant species. The areas above the upper grade control and along the right bank in the flats could be prepared to grow a combination of tall grasses and shrub that would ultimately bet flooded during the spawning season and may experience ponding and reconnection to the main channel of the river. The arrangement and location of this structure could provide the necessary process of nesting, early rearing and juvenile life histories for the pike an muskellunge species. Other specific structures and geometry of restoration will be maximized for other species targeted.

Large organic debris (LOD) will be placed to provide structure and cover for smallmouth bass, crappie, and muskellunge. In addition, the combination of loose and grouted boulders in conjunction with the LOD will provide areas where consistent water velocity provides a pool and chute environment excellent for sucker and other velocity oriented species.

Throughout this newly restored section of river, conditions will become more like prime habitat for the target species than as a fish passage reach of the river to ascend the dam or rapids.

<u>Recreation</u>

Whitewater Recreation - Canoe/Kayak
Impacts are very similar to Concept 1, except that the rapids are shorter and possibly lesser quality. This will decrease its attractiveness for whitewater recreationalists and make it more appealing for non-whitewater craft (marathon canoes, john boats, etc.).

Competitive Events
The rapids are too short for a slalom race or a whitewater rodeo. A marathon race could be run though the mild rapid, though a portage trail is provided.

Recreation on Depot Pond
Depot pond will increase in size from about 6 acres to 12 acres in this option. It will therefore have a greater surface area devoted to the uses commonly found there. Since it does not connect to the river it will have less sediment deposition than at present. The deeper pond will promote a better lake type of fish habitat and fishing.

Open Deck Canoeing
Inexperienced users would find the rapids intimidating at high flow and may result in upsets. A portage trail is provided. The length of free flowing river is increased and results in a more enjoyable paddle.

Power Boating
The Depot Pond becomes inaccessible to power boats using the river. In the immediate project area, the impounded area of the river is reduced by about 2/3 acre as a result of the area devoted to the rapid and the causeway to Duck Island. The water surface is lowered approximately four feet, reducing the overall impoundment by about one mile.

Land Based Recreation
A new causeway connects the west shoreline to downtown via Duck Island. There is the possibility of a pedestrian bridge from the east shore to Duck Island where it connects to a trail on the west shore. A continuation of the hike and bike trail through the Challenge

Mills property is possible in this scheme.

Alternative 4a ~Riffle/Pool River Restoration with Depot Pond

Description

This alternative removes most of the existing dam, and includes a series of islands, riffles and pools in the "free flowing" reach created by the significant lowering of the dam crest. Like Alternative 4, Depot Pond is maintained with its current water surface elevation and the inflow of sediment from the river is cut off. As with all of the alternatives, it has minimal impact downstream of the dam. The water surface elevation upstream of the dam is lowered so that only a natural-looking riffle appears at the location of the dam. This drop height is on the order of six to twelve inches. A small pool is located upstream and downstream of the existing dam, and several other riffles and pools are located between the dam and the Forest Preserve causeway, making up the remainder of this free flowing reach of the river. This alternative is shown on Drawings 9 and 10 and is illustrated in Figure 36 and 37. Figure 38 illustrates possible effects over time, if this alternative was shown with very minimal restoration.

Figure 39 is an aerial photograph from the early 1970's provided by the Mayor of Batavia during the October 23 public meeting. The picture shows the upstream reach after the dam was breached. Several key features shown in the photograph are very similar to those included in Alternative 4a. A floodplain overbank area is establishing in the upper right of the photograph. In addition, a natural berm is developing which closes off Depot Pond and an island is forming just upstream of Fabian Parkway. Figure 40 is a photograph taken at approximately at the same time. It is looking downstream from the establishing overbank area.

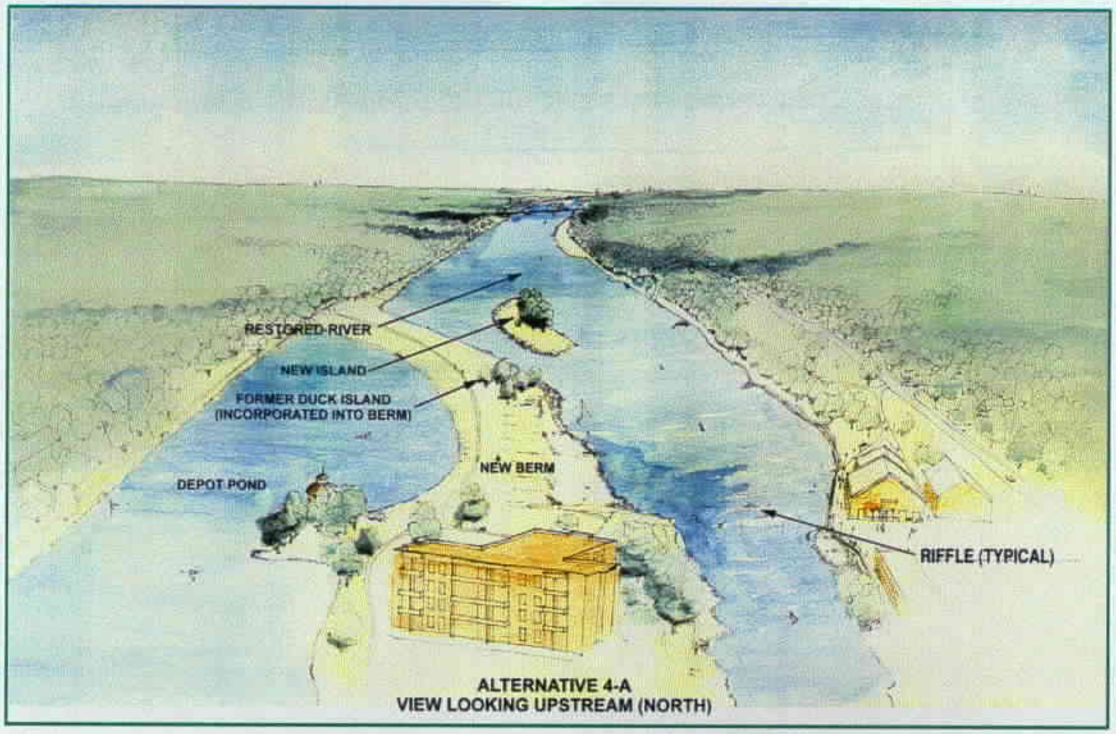
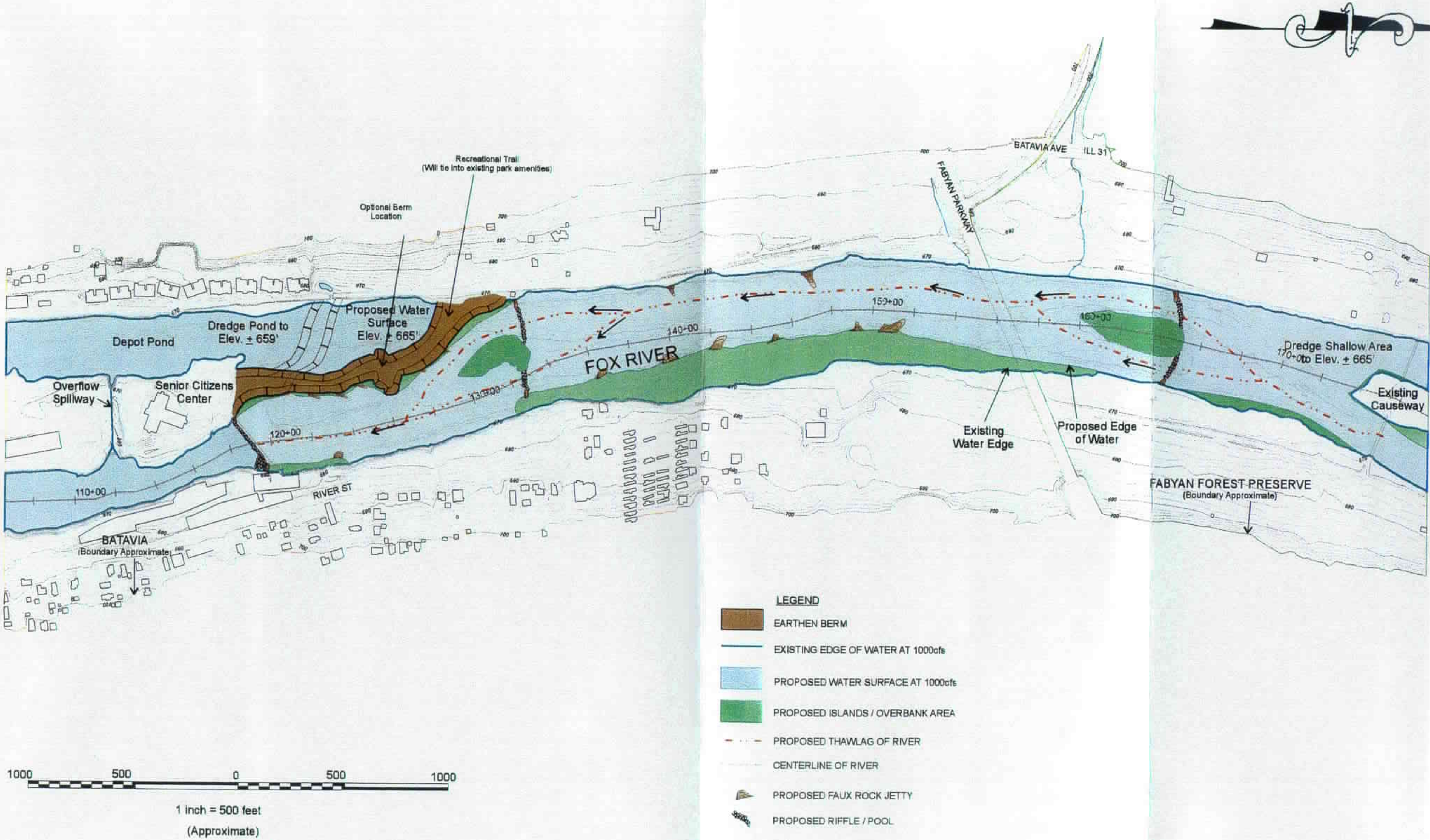
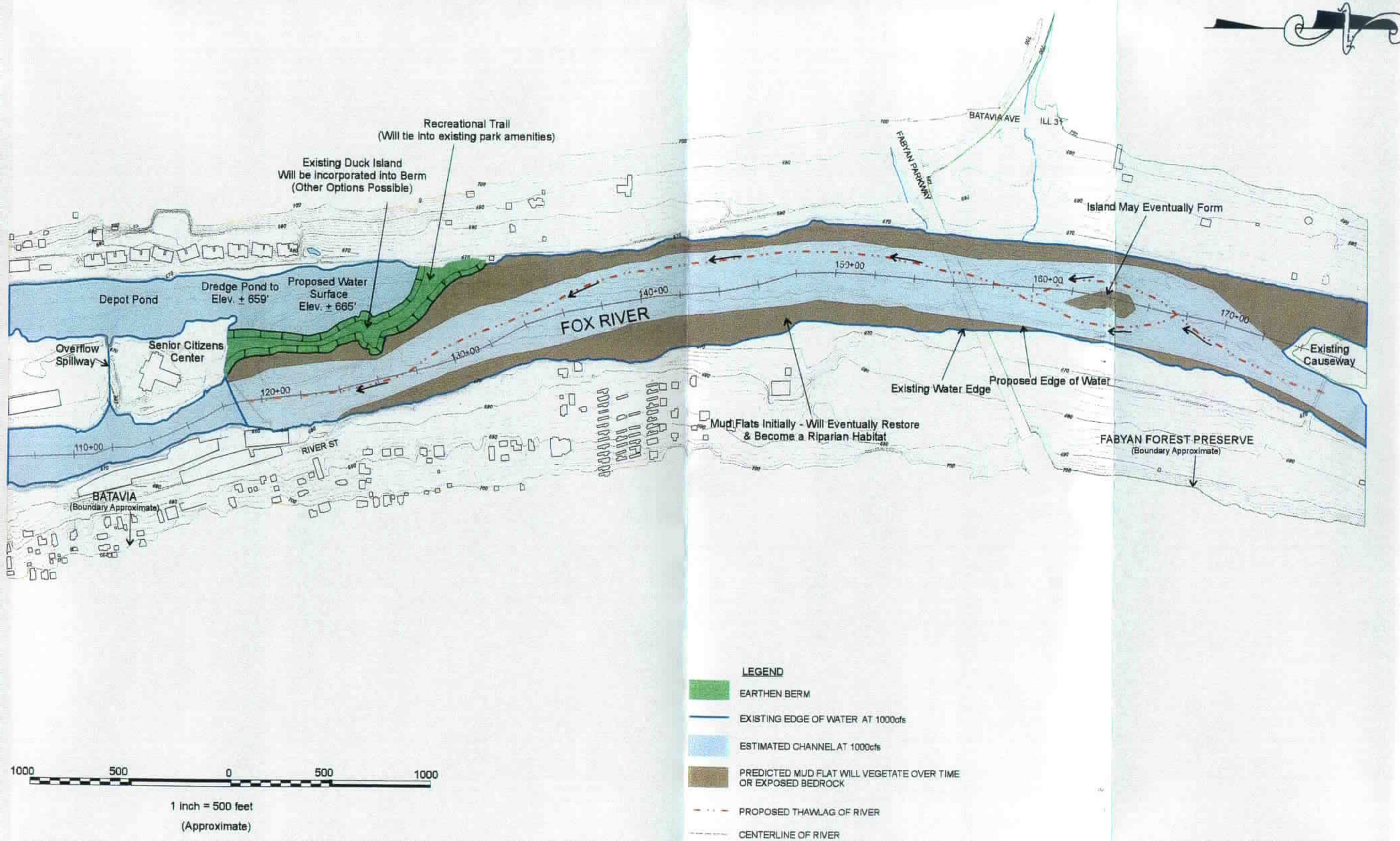


Figure 36 - Artist's Rendering of Alternative 4a


Recreational Trail
(Will tie into existing park amenities)
Optional Berm Location
Proposed Water Surface Elev. ± 665'
Dredge Pond to Elev. ± 659'
Depot Pond
Overflow Spillway
Senior Citizens Center
BATAVIA
(Boundary Approximate)
RIVER ST
110+00
120+00
130+00
140+00
150+00
160+00
170+00
FOX RIVER
BATAVIA AVE
ILL 31
FABYAN PARKWAY
Existing Water Edge
Proposed Edge of Water
Dredge Shallow Area to Elev. ± 665'
Existing Causeway
FABYAN FOREST PRESERVE
(Boundary Approximate)
LEGEND
EARTHEN BERM
EXISTING EDGE OF WATER AT 1000cfs
PROPOSED WATER SURFACE AT 1000cfs
PROPOSED ISLANDS / OVERBANK AREA
PROPOSED THAWLAG OF RIVER
CENTERLINE OF RIVER
PROPOSED FAUX ROCK JETTY
PROPOSED RIFFLE / POOL
1000 500 0 500 1000
1 inch = 500 feet
(Approximate)



Recreational Trail
(Will tie into existing park amenities)
Existing Duck Island
Will be incorporated into Berm
(Other Options Possible)
Depot Pond
Dredge Pond to
Elev. ± 659'
Proposed Water
Surface
Elev. ± 665'
Overflow
Spillway
Senior Citizens
Center
FOX RIVER
110+00
120+00
130+00
140+00
150+00
160+00
170+00
RIVER ST
BATAVIA
(Boundary Approximate)
BATAVIA AVE
ILL 31
FABYAN PARKWAY
Island May Eventually Form
Existing
Causeway
Existing Water Edge
Proposed Edge of Water
Mud Flats Initially - Will Eventually Restore
& Become a Riparian Habitat
FABYAN FOREST PRESERVE
(Boundary Approximate)
LEGEND
EARTHEN BERM
EXISTING EDGE OF WATER AT 1000cfs
ESTIMATED CHANNEL AT 1000cfs
PREDICTED MUD FLAT WILL VEGETATE OVER TIME
OR EXPOSED BEDROCK
PROPOSED THAWLAG OF RIVER
CENTERLINE OF RIVER
1000
500
0
500
1000
1 inch = 500 feet
(Approximate)

Figure 39 - Aerial Photo from the Early 1970s

As with Alternative 4, an earthen dam is constructed from the north end of the peninsula through Duck Island and to the east river bank. Drawing 9 shows two possible dam alignments. One connects to Duck Island, but the other leaves Duck Island as an island. The final alignment

Figure 40 - Looking Downstream from the Overbank Area.

location will be made based upon public and city input. In any alignment, the dam disconnects Depot Pond from the river and allows the existing water surface elevation to be maintained. A spillway is located at the Cut to prevent overflow into the pond from the basin. Benefits and further details of the improvements to Depot Pond are outlined above in Alternative 4.

Upstream restoration is much more extensive than included in Alternative 4. Depot Pond and (optionally) the Forest Preserve causeway pool are dredged to maintain pool depth, and sediment within the channel is stabilized in the form of floodplain overbanks. However, much more sediment is stabilized since there is very little impoundment and velocities associated with a free flowing river require a greater stabilization effort.

Other options at the causeway pond, such as restoration of the island would be investigated with the Forest Preserve.

Alternative 4a differs from Alternative 4 and the other alternatives in that stabilization efforts include the formation of islands, jetties, and riffles. Specific elements of stabilization include:

- creation of a low flow channel
- mid-stream islands
- vegetated floodplain overbanks
- three small riffles (six to twelve inch drop) distributed throughout the reach
- jetties
- selected areas of boulder or other types of toe protection

Creation of Low Flow Channel

A channel bottom is formed into a low flow channel. This confines the lower flows rather than spreading it across the width of the river.

Mid-stream Islands

As discussed in an earlier section, the majority of sediment is stabilized in place. The sediment is re-contoured to form several of islands. The purpose of these islands is several fold:

- They provide spoil areas for sediment
- They widen the channel so that the post dam river is closer in width to the impounded river and therefore less visual change for affected landowners.
- They promote secluded wildlife habitat as Duck Island currently provides.
- There is less impact to the existing channel banks while narrowing the channel.
- They visually tie into the string of islands that begin below Batavia and extend to Kane County Forest Preserve.

Vegetated Floodplain Overbanks

As described in the previous section, the wetland area of the channel becomes more narrow. In addition to the islands, it is also necessary to define an overbank area. The main overbank area, as depicted on Figure 28, is located on the east bank. This side of the river is parkland and has no private property frontage on the river. Therefore there is potentially less concern from landowners who loose river views (as would be the case on the west bank). In addition, the character of the parkland in much of this river reach (the Forest Preserve causeway downstream to Batavia) is heavily wooded and more natural than the areas further upstream. Here the hike bike trail is inland and does not have a view of the river. A naturalized sediment bar is a natural extension of the wooded shoreline, itself becoming wooded after a period of years. Since this is considered public property, it is available for future park development, provided that the proposed uses are consistent with its location in a floodplain.

Figure 41 - Stabilized Overbank Area

These overbank areas ultimately include wetlands and improved wildlife habitat throughout the entire reach. Combined with the improved fish habitat, there are also important positive effects on habitat for wading birds and ducks. Existing non-native species of shrubs and trees are replaced with native species thereby providing additional food and cover for wildlife.

Riffles and Pools

A riffle is a small vertical drop (6 inches +/-) within the thalwag of the channel. It is is a shallow area where the water surface is broken into waves by bed material, which is wholly or partially submerged. The purpose of the roughened riffle habitat is to increase water aeration, increase interstitial space and invertebrate productivity, provide fish habitat, and create the pleasant so-called "white noise."

Figure 42 - Riffle and Pool

Another purpose of the riffles is to provide a reliable flow split at the islands so that both channels remain active for flood conveyance, aesthetics, and aquatic and wildlife habitat.

The purpose of the pools is to dissipate energy during higher flows for channel stability, and to provide deeper cool zones for fish habitat. Pools are topographic depressions in the channel bottom produced (or at least maintained) by scour, and generally containing relatively fine bed material. Pools scour at high flow and fill in with sediments during low flows, whereas riffles silt in at high flows and scour during low flows. The scour and fill patterns for each stream permit pools and riffles to persist over a wide range of flows and over the long-term.

Jetties

A Jetty, or spur dike is defined as an elongated structure that has one end projected into the stream and the other end on the stream bank. Jetties have been used to help protect eroding stream banks, and enhancing aquatic habitats. The benefit of the jetty is that both stream banks, and aquatic habitats are improved. There are several types of jetties that are used with the main differences being impervious and pervious. Impervious jetties are aesthetically pleasing, have longevity, and protect eroding stream banks better than pervious jetties. Angled impervious jetties improve aquatic habitats by creating protected resting areas and deep scour pools, while still giving adequate protection to the stream banks.

Figure 43 - Photograph of Impervious Jetty Made of "Faux" Rock on the South Platte River, Denver, Colorado.

The ability of a jetty to help improve an eroding stream bank depends upon the design. Since a jetty is designed to protrude into the current of a stream, the jetty diverts the flow from the banks allowing the bank to stabilize. Aquatic habitat benefits are greatly influenced by the design of a jetty. Angled jetties create scour holes (perpendicular jetties do not) and these scour holes form stable pools even in unstable streams. The volume of the scour hole increases as the angle of the jetty increases. With a maximum angle of 135 degrees, the banks are still adequately protected from erosion. For aesthetics, bank stabilization, and habitat, Concept 4a includes angled impervious jetties made of faux (man-made) rock. Concept 4 relies upon buried or partially buried pervious jetties made of rip rap or loose boulders to provide bank stabilization only.

Toe Protection

A stable bank relies heavily upon the stability of the toe of the bank. The toe of the bank is at or near the bottom of the bank where it intersects the invert of the river. Toe protection will consist of rocks, boulders or concrete that can provide support and resistance to erosive forces while constantly being saturated. Because the upper portions of the bank are not constantly saturated, planted or seeded vegetation provides stability for the upper portion of the bank. Through stream bank stabilization, there is improved wildlife habitat along the stabilized portion of the new overbank. While narrow in some places, this wildlife corridor provides a relatively safe area for movement of wildlife species along the river.

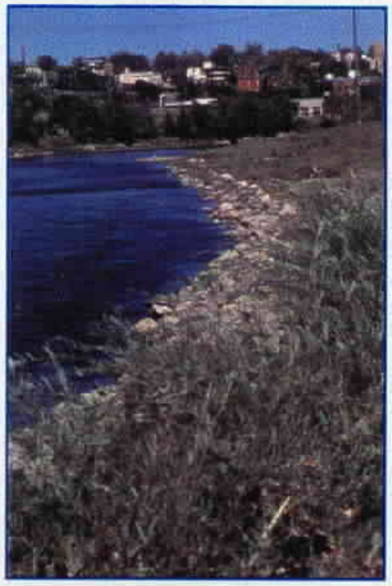


Figure 44 - Toe Protection on the South Platte River, Denver, Colorado.

Fish Passage

This option restores this reach of river to nearly pre-dam conditions. The extremely mild gradient of about 5 feet per mile contrasts with the 26 feet per mile gradient of the previous alternatives. The three small riffles will have roughness elements to slow velocities and create pools for improved habitat. It will be sloped in a downward direction from the shore towards the thalwag to avoid the typical problems of uniform water depth and velocity at weirs. The riffles will provide the most transparent fish passage for the widest range of species through the greatest range of flows.

Another benefit of the riffles is to improve the dissolved oxygen levels for fish and aquatic habitat. Several applications and model studies have proven the effectiveness of small drops in relatively flat river reaches in equilibrating the dissolved oxygen concentrations back to a balance at ambient conditions. Cascades and riffles will provide habitat and roughness to transform poor gas conditions that may exist during high biological oxygen demand seasons (spring and summer) into water quality that is acceptable for aquatic species.

Recreation

Whitewater Recreation - Canoe/Kayak

Without the drop in the dam, opportunities for whitewater canoe/kayak are non-existent. Opportunities for flatwater canoe/kayak increase with the restoration of the free flowing river.

Open Deck Canoe

This alternative creates a mild gradient river suitable for open canoes piloted by persons without much moving water experience. If combined with other dam removals, such as the lower Batavia Dam, then a significant stretch of free flowing river is created. In this case a river trail is possible, creating a long trip and economic opportunities for those providing services in this market (e.g. canoe livery, float fishing guide services, etc.) Riffles, pools, and jetties provide excellent hydraulic features that create interest for canoes.

Power Boating

Since the impoundment is eliminated, most power boating also disappears. The possible exception is small flat-bottom boats capable of operating in shallow shoals and moving water. A qualitative test would be needed to assess the boatability of the project area in this type craft.

Competitive Events

There would be no rapids that permit a slalom race or a rodeo event. A marathon race could be run on the restored river channel, without the need for a portage.

Recreation on Depot Pond

Depot pond increases in size from about 5 acres to approximately 9 acres in this option. It therefore has a greater surface area devoted to the uses commonly found there. Since it does not connect to the river it will have less sediment deposition than at present.

Land Based Recreation

A new causeway connects the west shoreline to downtown via Duck Island. There is the possibility of a pedestrian bridge from the east shore to Duck Island where it connects to a trail on the west shore. A continuation of the hike and bike trail through the Challenge Mills property is possible in this scheme.

Alternative 5 - Whitewater Rapid through Town Center

Description

As with Alternatives 2 and 3, the new stepped dam is located near the current location. An off-channel whitewater bypass runs through the center of town. This alternative was initially looked at in conjunction with a long range plan developed by the City's planning department. The City's original plan included a non-boating water feature along the proposed route as shown on Drawing 11. After a brief analysis, it was considered very expensive and difficult to implement. Much private land needs to be acquired and significant infrastructure needs to be relocated or modified. Because the City is not currently interested in pursuing this effort, Alternative 5 was eliminated during the initial evaluation process.

Fish Passage

Since this alternative has been dropped from further consideration, recreation impacts are not relevant.

Recreation

Since this alternative has been dropped from further consideration, recreation impacts are not relevant.

ALTERNATIVE EVALUATION

Design Objectives
To various degrees, Alternatives 1, 3, 4, and 4a all meet the stated design objectives. Each alternative addresses some objectives better than others. Each alternative as it relates to their ability to meet the objective is summarized below:

Safety
Alternative 4a is very low hazard since it has only three small vertical drops, one at the dam and two more at upstream locations. In terms of whitewater rafting, excitement and challenge equate to some amount of risk. Alternatives 1 and 4 have some challenge for the whitewater enthusiast and therefore has risk similar to that of a natural Class II Rapid. For the most part Alternative 3 will have similar risk, however since it is more confined and has a higher recreational value, this alternative may have slightly more risk. In addition, Alternative 3 also includes a step dam, which is not present in Alternatives 1 and 4. While much safer than conventional dams, the stepped dam does not totally eliminate the safety problems related to low-head dams. All of the alternatives are lower hazard than the existing dam.

Flood Conveyance
While Alternative 2 does not meet the flood conveyance objectives, the remainder of the alternatives do. Alternative 1 lowers the water surface elevation from the location of the existing dam upstream to Duck Island. Upstream of Duck Island, Alternative 1 has no appreciable impact on the exiting flood conveyance of the channel Alternatives 4, and 4a lowers the normal pool elevation to the Forest Preserve causeway. Lowing the water surface increases flood conveyance through that stretch of the river. Alternative 3 has minimal impact on the existing flood conveyance of the channel and therefore meets criteria set for existing conditions.

Upstream Pool
Alternative 3 maintains the upstream pool throughout the entire reach. Alternative 1 maintains the current pool upstream of Duck Island. Alternatives 4 and 4a lower the pool behind the location of the existing dam, however they impound water in Depot Pond at current water surface elevation of 665 feet.

Cost Effectiveness
Costs are summarized in the following section. Alternatives 1, 4 and 4a have similar costs and for purposes of the evaluation, there is little significant differences. Alternative 3 is the lowest cost alternative.

Fish Passage
All of the alternatives incorporate fish passage into the multi-purpose dam replacement project. Alternative 4 and 4a exhibit the least amount of hydraulic drop and therefore are the least restrictive to fish passage. Both incorporate a roughened channel approach that mimics and enhances the native Fox River channel morphology. These two alternatives meet the initial design objectives and goals. All target species of fish will be able to ascend this section of the river once it is restored as described in the alternative descriptions and drawings. Target species of fish are adults and sub-adults in size and age. Juvenile and sub-juvenile fish are by virtue of their size weaker swimmers and will have difficulty passing over obstacles at high velocities caused by high flow conditions. Juvenile pike and crappie, the weakest motivated and weakest swimmers will be able to ascend across alternative 4 and 4a.

Alternative 1 and 3 exhibit a more confined roughened channel arrangement. It is anticipated that the weak swimmers such as pike will ascend through the roughened channels by virtue of their swimming ability and the associated velocities that will allow them to pass rest and swim again until reaching the fish exit of the passage section. The pike behavior may limit the actual numbers of fish passing over the project. As discussed earlier the fish exit for alternative 3 is problematic. It must control flow into the channel and allow fish to easily exit through a chute velocity appropriate for passage. In addition the multiple attraction flows exhibited by Alternatives 1 and 3 create delays and potential for poor target fish passage. The vertical slot fishway associated with Alternative 3 works well for salmonid species but is not as successful for target fish species of the Midwest. The vertical slot fishway however is the best solution for a refined concrete fishway for Midwest target fish species if constructed correctly.

In Table 6, Fish Passage Evaluation Summary Matrix each alternative is displayed and a statement of pros and cons is presented. The table shows the various criteria and descriptions for each alternative and whether they are met or not. In the column titled Species of Fish Passed, a qualitative statement of the identified target species that will pass is noted. No quantitative indication of juvenile or fry fish passage success of the target fish species is developed as that is outside the criteria established in the design memorandum.

	Roughened Channel Goals	***Public Observation Opportunity***	***Fish's Eye Passage Velocity Goals***	***Debris Fouling Potential***
ALTERNATIVE 1	Are met	Poor Opportunity	Slope is appropriate	Low
ALTERNATIVE 2	Not applicable.	Fair Opportunity	Slope is appropriate	Medium
ALTERNATIVE 3	Are Obtainable but confined	Fair to Good along white water channel	Slope is appropriate	Medium
ALTERNATIVE 4	Are Obtainable	Poor Opportunity	Slope is appropriate	Low
ALTERNATIVE 4a	Not applicable natural river bed is created.	No fish passage observation opportunity	Is Obtainable	Low

	Fish Resting Pool Size Goals	***Fish Entrance to Fish Passage Area***	***Fish Exit to Fish Passage Area***	***Passage of Fish***
ALTERNATIVE 1	Are obtainable.	Is acceptable for fish passage.	Is acceptable.	Provides passage for most species upstream, but weak swimmers may have less opportunity for passage upstream during certain low flow regiemes. Provides fish passage pathways for all fish species present.
ALTERNATIVE 2	Are Constrained	Difficult to find.	May provide predator opportunity.	There is poor fish attraction. Confusing flow patterns for fish passage, and a dead end barrier at new step dam.
ALTERNATIVE 3	Are Constrained	There are confusing flow patterns for fish passage at different flow rates. Attraction flows occur at three locations; the whitewater course, the dam face right bank, and the dam face left bank.	Pond exit may provide predator access. Exit of white water channel may be confusing and cause some delay.	Fish behavior may not result in good fish passage through fishway as expereenced in other Midwest installations. Pasage of fish upstream through whitewater course will limit the species to strong swimming fish. Fish may exhibit long travel time in whitewater course.
ALTERNATIVE 4	Are Obtainable	During certain flow regimes attraction may occur at two places, the whitewater channel and the low flow fish passage channel.	Is acceptable.	Weak swimming fish may have problems ascending at the weir crossings in the low flow channel, and they also may experience problems from passing upstream.
ALTERNATIVE 4a	Are Obtainable	All fish passage is possible for a wide range of flow regimes.	Is acceptable.	All fish species have an opportunity to pass upstream. Fish passage and travel time will be as experienced in the natural river.

Table 7 - Fish Passage Evaluation Summary Matrix

Boat Passage

All of the alternatives incorporate boat passage. Alternatives 1, 3 and 4 provide the best passage for whitewater kayakers. Alternative 4a provides passage for all types of river craft including open deck canoes.

Maintenance

Maintenance of the structures is minimal for all of the alternatives. Alternatives 1 and 4 will require some debris removal. Alternative 3 will require a slightly higher effort for debris removal since the channel is narrow. Additionally, Alternative 3 will require some debris removal at the dam and the fish ladder. Alternative 4a will require the least amount of maintenance since there is little to "hang" debris.

Alternatives 1, 3, and 4 may need some initial adjustment in the whitewater course. Experience has shown that even with diligent design and physical modeling effort, some minor adjustment is often needed. This is usually completed immediately after construction or within the first year or two. Alternative 4a may need some relatively minor improvements within the first couple of years for local bank or scour protection.

River Restoration

Alternatives 1 and 3 require virtually no restoration from the design itself, however Alternative 3 may require restoration from the impacts of construction since much of the construction takes place through the Cut. Alternative 4, and to a greater extent 4a, will require upstream restoration efforts due to the lower upstream water surface elevation. If left untouched, the lower upstream water surface elevation in the river would destabilize existing sediment and banks.

Environmental Impacts

For the most part, Alternatives 1 and 3 are similar to existing conditions both upstream and downstream. Alternatives 4 and 4a will have positive upstream environment impacts in that river velocity will be increased, and more floodplain overbank created. Assuming that only minimal amounts of sediment are released downstream, then Alternatives 4 and 4a will have virtually no downstream environmental impacts.

All of the alternatives will have a positive impact on the minimum levels of dissolved oxygen (DO) in the reach downstream of the existing dam. Alternative 4 will provide some increase in minimum DO levels (due to the increased velocity) upstream of the dam. Alternative 4a will significantly increase minimum levels of DO in the upstream reach since it consists of a series of small riffles that will act to aerate the water.

Depot Pond

Alternatives 4 and 4a will make significant improvements to Depot Pond. By removing the sediment supply, the pond will remain deeper, cooler, and create a better pond-type of aquatic habitat. This will also result in long term cost savings related to sediment removal. In Alternative 3, Depot Pond is more hydraulically connected to the channel than it is now. This will result in better circulation from the increase in flow through the Cut and will tend to carry sediments through the pond rather than dropping them in the pond. Therefore, the whitewater course would act to reactivate this river arm rather than leaving it as a dead-end that will naturally tend to fill in with sediment.

City Planning

Alternatives 1, 4 and 4a follow very closely with the planning and goals of the City of Batavia. Alternative 3 may focus more attention to the senior citizen residence than the City desires.

Cost Evaluation

Alternatives that were deemed worthy of further investigation by the IDNR design team and representatives from the City of Batavia, were evaluated on a capital cost basis. For the purpose of comparison, capital costs were approximated for each alternative. This was accomplished using a typical unit cost estimating basis. Assumptions and rough calculations were made on these alternatives so that quantitative estimates of construction materials could be produced. Unit costs for installed materials from other similar jobs were adjusted for local conditions and then applied to the estimated installed materials needed for each alternative. The comparative costs for each alternative is summarized in Table 7.

The estimates above are based upon limited design and field information. While sufficient for a rational comparison of alternatives, detailed preliminary design based upon adequate field information and analysis is necessary before a reliable statement of probable cost can be made.

From this analysis, Alternatives 1, 4 and 4a are all of similar magnitude and for evaluation purposes can be considered roughly approximate. Alternative 3 has a significant difference in cost and is clearly the lowest cost alternative. This is expected since it takes advantage of the Cut, which can be looked upon as an existing and partially completed whitewater course.

Development of the Statements of Probable Cost

Following are brief explanations of the individual unit costs and quantities that the above table and alternative totals are based.

General Site Costs

Construction mobilization is included at 5% of the total project cost. General dewatering costs include the dam area only, and are based upon sheet piling, earthwork and pumping costs. Lesser amounts of effort and cost related to dewatering are included in the unit costs, used for the estimate. A lump sum amount has been allocated for site access and for relocating utilities.

Costs Associated with Dam

EARTHWORK AND ARMORING

Total estimates of cut and fill are based upon existing and proposed grading in the dam area. Excavation and disposal of unsuitable material exists upstream of the existing dam structure. Riprap, used for erosion control and placed on the berm or earthen dam and Duck Island was included from the toe of the slope to the 100-year flood event. Over-bank armor, most likely riprap, and whitewater channel armor, most likely roller-compacted concrete, will be used to cover newly excavated channel for stability and erosion control.

MODIFY OR REPLACE EXISTING DAM

Demolition of the top of the concrete dam to the desired height includes concrete disposal. Assumptions on the viability of using portions of the existing dam were made on appropriate alternatives. Costs included excavation, preparation of sub-grade, and repair of the breached section of the dam.

NEW DAM

Costs were evaluated for Layered Grouted Boulders (LGB) and Roller Compacted Concrete (RCC). Based upon site conditions, local rock availability and cost, RCC was the lower cost material and was selected for the purposes of cost estimating. During future design efforts portions of the new dam or other features may be designed using other concrete/rock materials. Foundation preparation includes stabilized

STATEMENT OF PROBABLE COSTS
Table 8

Item	Repair Exist. Dam	Alternative 1	Alternative 3	Alternative 4	Alternative 4a
General Site Costs					
Mobilization (5% total)	$70,000.00	$310,000.00	$220,000.00	$330,000.00	$320,000.00
Dewatering	$70,000.00	$220,000.00	$150,000.00	$160,000.00	$50,000.00
Site Access	$50,000.00	$50,000.00	$50,000.00	$50,000.00	$50,000.00
Subtotal	$190,000.00	$580,000.00	$420,000.00	$540,000.00	$420,000.00
20% Contingency	$38,000.00	$116,000.00	$84,000.00	$108,000.00	$84,000.00
Total - General Costs	$228,000.00	$696,000.00	$504,000.00	$648,000.00	$504,000.00
Costs Associated with Dam					
Earthwork					
Cut		$20,000.00		39,200.00	$13,500.00
Compacted Fill		$489,600.00		306,800.00	
Berm Riprap		$35,000.00		$42,250.00	$8,600.00
Overbank Armor		$1,600,000.00		$755,000.00	
Remove and Replace Unsuitable Material*		$262,500.00		$210,000.00	
Modify or Replace Existing Dam					
Demolition/Debris Removal	$42,000.00	$96,000.00	$60,000.00	$96,000.00	$96,000.00
Rock Excavation	$15,000.00	$9,000.00	$21,000.00	$8,400.00	$8,400.00
Subgrade Prep	$20,000.00	$6,000.00	$20,000.00	$6,000.00	$6,000.00
Dam Material	$120,000.00	$12,000.00	$306,000.00	$9,600.00	$9,600.00
Spot Repairs	$75,000.00				
New Dam					
Rock Excavation		$63,000.00		$48,000.00	
Subgrade Prep		$40,000.00		$32,000.00	
Dam Material		$450,000.00		$300,000.00	
New Dam Abutments					
Rock Excavation	$22,500.00	$22,500.00	$22,500.00		
Subgrade Prep	$16,000.00	$16,000.00	$16,000.00		
Dam Material	$198,000.00	$132,000.00	$132,000.00		
Intermediate Grade Control Structure					
Rock Excavation		$24,000.00			
Subgrade Prep		$16,000.00			
Dam Material		$132,000.00			
Abutment along Building / Grade Wall (river left)					
Site Excavation and Backfill	$30,000.00	$30,000.00	$30,000.00	$20,000.00	$20,000.00
CIP Concrete	$260,000.00	$247,500.00	$260,000.00	$225,000.00	$225,000.00
Retaining Wall Removal and Replace	$18,000.00		$18,000.00		
Berm and Duck Island Enlargement					
Clay Core		$104,000.00		$94,900.00	
Floodwall					
Floodwall (CIP Concrete)	$36,000.00	$36,000.00	$36,000.00		
Subtotal	$852,500.00	$3,843,100.00	$921,500.00	$2,193,150.00	$387,100.00
20% Contingency	$170,500.00	$768,620.00	$184,300.00	$438,630.00	$77,420.00
Total - Costs Associated with Dam	$1,023,000.00	$4,611,720.00	$1,105,800.00	$2,631,780.00	$464,520.00
Canoe and Fish Passage					
Cut		$20,000.00	$115,000.00	$9,800.00	
Compacted Fill		$54,400.00	$7,200.00	$23,600.00	
RCC Berm			$102,000.00		
Whitewater Channel Armor		$300,000.00	$288,000.00	$140,000.00	
Overbank Armor			$375,000.00		
Remove and Replace Unsuitable Material*		$487,500.00		$390,000.00	

STATEMENT OF PROBABLE COSTS
Table 8

Item	Repair Exist. Dam	Alternative 1	Alternative 3	Alternative 4	Alternative 4a
Fish Passage Appurtenances	$480,000.00	$75,000.00	$480,000.00	$55,000.00	$55,000.00
New Vehicle Bridge and Ped. Path					
Bridge			$350,000.00		
Road and Paving			$7,000.00		
Maintain Existing Ped. Bridges and Path					
Path			$17,500.00		
Bridge Structures (90' and 50')			$140,000.00		
Headgate Structure					
CIP Concrete			$13,500.00		
Inflatable Dam Structure			$400,000.00		
Subtotal	$480,000.00	$936,900.00	$2,295,200.00	$618,400.00	$55,000.00
20% Contingency	$96,000.00	$187,380.00	$459,040.00	$123,680.00	$11,000.00
Total - Canoe and Fish Passage	$576,000.00	$1,124,280.00	$2,754,240.00	$742,080.00	$66,000.00
Channel Restoration					
Water Control				$150,000.00	$250,000.00
Cut				$163,500.00	$337,500.00
Fill					$787,500.00
Haul and Disposal, and/or reuse				$1,090,000.00	
Topsoil				$98,000.00	$98,000.00
Dryland Seeding				$72,000.00	$72,000.00
Island Stabilization @ front					$111,000.00
Toe Stabilization					$338,000.00
Jetties					$1,200,000.00
Upstream riffles/ grade control					$289,000.00
Recreation/Portage Trail		$36,000.00		$33,000.00	$33,000.00
Landscaping Budget		$50,000.00	$50,000.00	$50,000.00	$50,000.00
Remove Sediment at Forest Preserve				$560,000.00	$560,000.00
Subtotal	$0.00	$86,000.00	$50,000.00	$2,216,500.00	$4,126,000.00
20% Contingency	$0.00	$17,200.00	$10,000.00	$443,300.00	$825,200.00
Total - Channel Restoration	$0.00	$103,200.00	$60,000.00	$2,659,800.00	$4,951,200.00
Depot Pond Enhancement					
Remove sediment in Depot Pond / Disposal		$960,000.00	$960,000.00	$960,000.00	$960,000.00
Improve Flow through the "Cut"		$90,000.00		$90,000.00	$90,000.00
Modify Channel for Lake Overflow				$15,000.00	$15,000.00
Berm and Duck Island Enlargement					
Clay Core				$51,100.00	$146,000.00
Pump and Equipment				$65,000.00	$75,000.00
Cut					$13,500.00
Compacted Fill				$141,600.00	$412,000.00
Berm Rip Rap				$22,750.00	$77,400.00
Subtotal	$0.00	$1,050,000.00	$960,000.00	$1,345,450.00	$1,788,900.00
20% Contingency	$0.00	$210,000.00	$192,000.00	$269,090.00	$357,780.00
Total - Depot Pond Enhancement	$0.00	$1,260,000.00	$1,152,000.00	$1,614,540.00	$2,146,680.00
TOTAL	$1,827,000.00	$7,795,200.00	$5,576,040.00	$8,296,200.00	$8,132,400.00
6% increase for later construction	$109,620.00	$467,712.00	$334,562.40	$497,772.00	$487,944.00
GRAND TOTAL	**$1,940,000**	**$8,260,000**	**$5,910,000**	**$8,790,000**	**$8,620,000**

dolomite foundation, cutoff walls at the upstream and downstream toe, and are assumed to key three feet into bedrock. The dam has a crest width between 6 feet and 10 feet, depending on overall height, a 2:1 slope on the downstream side, and a 1:1 slope on the upstream side.

NEW DAM ABUTMENTS

Roller compacted concrete masses anchor the dam into bedrock on river left and into the new berm on river right. The abutments extend down to the bedrock.

INTERMEDIATE GRADE CONTROL STRUCTURE

This applies to Alternative 1 and is of the same type and construction as the new dam.

ABUTMENT ALONG BUILDING (RIVER LEFT)

This wall is a 15-foot to 18-foot tall concrete wall. It is anchored three feet into bedrock and has a footer. The total length is approximately 275 feet.

BERM AND DUCK ISLAND ENLARGEMENT

The majority of the alternative costs are in the earthwork and armoring costs. This includes a ten foot wide compacted clay core to prevent seepage. Unit costs were based upon local information and projects.

FLOODWALL

This applies to alternatives 1, 2, and 3 and includes a two-foot grade floodwall to protect and provide freeboard for the senior citizen residence.

Canoe and Fish Passage

This includes the same items as for earthwork and armoring. In addition, it includes fish passage appurtenances. Internal structures, which form the hydraulic features, were costed using percentages of RCC, fill, and flexible surface armoring.

NEW VEHICLE BRIDGE AND PEDESTRIAN PATH

This applies to Alternative 3 - a new two-lane vehicle bridge, approximately 15-feet tall, and spanning 50 feet over the white water course is included. Engineers familiar with bridge costs estimated a lump sum cost of $350,000.

MAINTAIN EXISTING BRIDGE AND PATH

This applies to Alternative 3 and includes removal and replacement of the existing path, and two pedestrian bridges, one spanning 85 feet, the other 55 feet over the whitewater course.

HEADGATE STRUCTURE

This applies to Alternative 3 - cast in place concrete structure to support a 20-foot wide, 6-foot tall, inflatable dam to control water flow into the whitewater course.

Channel Restoration

This item applies to Alternatives 4 and 4a.

Alternative 4 - Water control for the upstream restoration was estimated and adjusted based upon restoration length. Cut and fill quantities for channelizing and deepening the river along the thalwag are included as shown in the table. Most of the material from cut quantities was used for upstream fill. Limited excess material is hauled offsite and is disposed of at a landfill. Topsoil and seeding is applied for the restored areas above the bank-full water level. <u>Note: Costs for disposal of hazardous material were not used in the cost estimates</u>.

Alternative 4a was estimated similar to Alternative 4, but with more extensive water control and channelizing. Cut and fill were balanced for the upstream channel modifications (i.e., there is no net import of fill into the channel). Unit costs for fill include temporary storing the material on site for drying. Topsoil and seeding was applied for the restored areas above the bank-full water level. Island stabilization includes excavating to bedrock at the upstream end of the islands and a grouted rock mass on the leading edge of the island. Toe stabilization includes riprap down 3 feet below ground level around the remainder of the island.

The jetties include stabilization (similar to the islands), reinforced low-strength concrete and topped with faux rock (pneumatically applied concrete). Pneumatically applied concrete is colored and sculpted to match the natural rock in the area.

Depot Pond Enhancement
Removal and non-hazardous off-site disposal of sediment in Depot Pond and the Forest Preserve Pond is included. The unit cost is based upon local experience and projects. Improved flow through the Cut for Alternatives 4 and 4a is included for lake overflow. All the other alternatives include costs for an inlet structure to increase the flow through the Cut.

BERM AND DUCK ISLAND ENLARGEMENT
This applies to Alternative 4 and 4a - Earthwork and Armoring costs for earthen dam and berms include a ten-foot wide compacted clay core to prevent seepage, and foundation of the dam on bedrock. A small pump and supply line to provide water to a newly constructed pond is included.

Finally, the estimates include a 20 percent contingency for unknown construction efforts that are unanticipated at this level of study. In addition, a six percent increase in cost was used to escalate construction costs to 2001/2002 dollars. Costs shown are indicative of construction costs and do not include various project related costs. Costs for engineering, physical modeling, surveying, geotechnical investigations, permitting, construction inspection, various administrative costs, land acquisition, maintenance and operations costs are not included.

<u>Comparison to Previous Study</u>
To evaluate the reasonableness of the costs presented above, a comparison to the previous study and subsequent estimate is presented.

The previous study by the University of Illinois, presented three alternatives for dam replacement only. Cost estimates were not included in the study, however a cursory estimate was subsequently made by IDNR personnel. The $5,000,000 estimate was based upon the upward pointing stepped V-dam alternative. The estimate did not include fish or boat bypass. Based upon previous projects, a cost for a separate boat chute bypass would be on the order of $200,000 per vertical foot, or $2 million for this approximate 10-foot drop. If included with the original V dam cost estimate, the total cost for the V dam and boat chute bypass would be on the order of $7,000,000. Based upon this very crude check, the integrated dam and whitewater passage alternatives presented in this study appear to be reasonable.

Qualitative Evaluation
Alternatives can be evaluated using many different methods. Cost evaluation is the most objective, however with the uniqueness of the alternatives presented, subjective evaluation regarding the desirability or beneficial value of each alternative is necessary.

To assist in the comparison of alternatives, the design team has summarized the anticipated comparative performance in three categories including:

1. Whitewater recreational quality
2. Open deck canoeing recreational quality
3. Aquatic habitat quality

Figure 45 - Whitewater Recreational Quality

Figure 46 - Open Deck Canoeing Recreational Quality

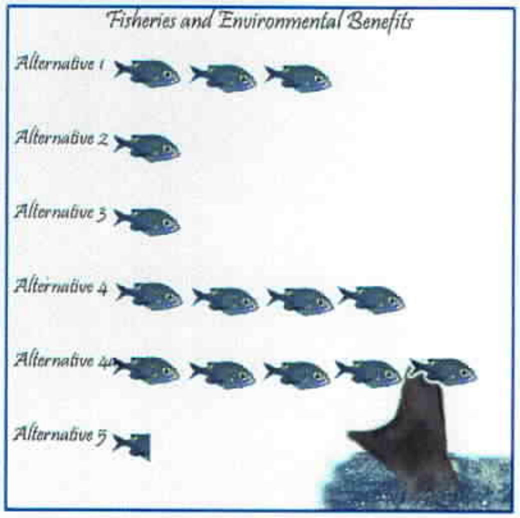


Figure 47 - Aquatic Habitat Quality

May 2000 Work Session

During the work session on May 23, 2000, local stakeholders from the city including City Councilmen, city employees from the parks and engineering departments, along with a state representative, a representative from Kane County Forest Preserve and representatives from boating interests, voted on their favorite alternative. The alternatives presented to the group by the IDNR design team were essentially the same as presented in this report with one exception, Alternative 4a. At this time Alternative 4a was under development and did not include restoration elements and recreational amenities as now presented.

Participants were asked to rate their first and second choices. Results are shown in Table 9.

Alternative	First Choice	Second Choice
Alternative 1 - Full Width Whitewater Rapid	7	
Alternative 2 - River Right Whitewater Bypass		
Alternative 3 - Whitewater Course Through The Cut		
Alternative 4 - Small Rapid with Depot Pond	4	4
Alternative 4a - Riffle/Pool River Restoration with Depot Pond	2	2
Alternative 5 - Whitewater Course Through Downtown Batavia		

Table 9 - Alternative Ranking

October Public Meeting

A public meeting was held October 23, 2000 at the Batavia Town Hall. All of the alternatives were presented along with the preliminary results of the Max McGraw Wildlife Foundation study. In addition, an option similar to alternative 4a was presented by Friends of the Fox. After the presentation, members of the audience were encouraged to make comments or ask questions.

Some comments and concerns included:

- Concerns about the potential effect to the Forest Preserve if a dam lowering/removal option is chosen.
- Concerns about the effect of a lower water surface elevation to the upstream pool.
- Concerns with Alternative 4a and the optional bike path located along the Riverwalk (this optional bike path has since been removed from the drawings).
- Comments on the positive impacts with one of the dam removal options and the benefits to fish habitat.
- Comments on the costs associated with the dam removal option presented by Friends of the Fox.
- This is a family oriented area - we do not want to see alternatives 1,2,3 or 5 constructed.
- Would like to see further evaluation of the dam removal options.

While no formal decision has been made at this time, it appears to be the general consensus that alternatives 2, 3, and 5 do not need any further evaluation.

Alternative Evaluation Matrix

As demonstrated above, it is highly unlikely for the stakeholders involved in the selection recommendation to all have the same opinion when addressing the subjective quality or benefit of each alternative. One method that is somewhat more detailed than the rating conducted during the May 23, 2000 work group meeting, is developing an evaluation matrix. This method has participants develop categories such as aesthetics, safety, and recreation. The participants then vote on an importance or weighting factor to give each of the evaluated categories. After this, stakeholders rate each of the alternatives by category on a scale of 1 to 10. The sub-totals for each category are then multiplied by the category-weighting factor and are summed for each alternative. The total can then be normalized to a scale of

Replacement of the Upper Batavia Dam Alternative Ranking						
Category	Point Value	Alternative				
		1	2	3	4	4a
Whitewater Boating						
Flatwater Canoeing						
Motor Boating						
Aquatic Habitat						
Fish Passage						
Safety						
Enhancement to Depot Pond						
Depot Pond Recreation						
Land-Based Recreation						
Cost						
Water Quality						
Sediment						
Maintain Existing Shoreline						
Total Ranking						
Normalized out of 100						

Table 10 - Sample Matrix

100 to give a consensus opinion of the stakeholders.

A summary of these tasks is as follows:

I. Define categories of important factors.
II. Rate each of the categories according to a mutually agreed to or voted point value.
III. Have represented stakeholders rate each of the alternatives relative to each category.
IV. The matrix will multiply the point value by the weight for each category and for each alternative.
V. This will rank each alternative based on all of the selected categories.

The sample matrix above depicts a list of possible categories.

Alternative Selection and Modeling

Depending upon the selected alternative, physical modeling of the alternative maybe needed within the following preliminary design phase of work. Alternative 4a would not require physical modeling. Physical modeling would be beneficial for Alternative 4, and necessary for Alternatives 1 and 3.

The existing modeling facilities at Urbana would probably not provide enough detailed information to create the high quality rapid in Alternatives 1 and 3. For these options a new or second larger scale model of about 1:12 is necessary. Limited information from the existing model may be suitable for Alternatives 4 and to evaluate local armoring requirements in the vicinity of the proposed earthen dams in Alternatives 1, 4, and 4a.

A detailed two-dimensional sediment transport and deposition computer modeling effort for Alternatives 4 and 4a is appropriate to predict and refine the size, location and orientation of the proposed features. Physical modeling could also accomplish this. A determination using input from Dr. Garcia at the Civil Engineering Department in Urbana should be made.

SUMMARY

Replacement of the Batavia Dam with a multi-purpose dam that includes whitewater recreation and fish passage is progressive by current national standards. While the technology is over 25-years old, there are only a handful of new low-head dams that have been built in the US in this fashion. The approach is holistic in that it addresses concerns and objectives of a wide variety of interests by integrating flood control, recreation, fish habitat, environmental, and aesthetic concerns.

The alternatives presented in this report provide a different focus on environmental, recreation, planning, and aesthetic issues. As with other dams currently being reviewed by the IDNR, this project was initially conceived as a dam replacement with the possible addition of added fish passage and boat chute bypass. Alternative 3 is the only alternative that meets this initial conception. The other alternatives were developed as a result of innovative thought processes and an integrated approach with the IDNR design team and representatives of the City of Batavia.

The alternatives developed by the IDNR design team provide a wide range of options and choices for the Batavia Dam replacement project. Alternatives 1 and 3 create a very high quality whitewater rapid that would certainly become a regional attraction for whitewater enthusiasts. Alternative 3 is the least cost alternative, but has the most impact on local community planning. Alternative 4a returns the river to a free flowing river, which optimizes fish habitat and open deck canoeing recreation. Alternative 4 falls somewhere between Alternatives 1 and 4a.

The alternatives presented are not "set in stone." Rather, they represent a logical inclusion of design elements arranged in a fashion that optimizes and integrates various <u>interdependent</u> goals and objectives. "Options" to each alternative can be thought of as items or design issue that address <u>independent</u> goals or objectives. An example of an "option" is found with the earthen dam that isolates Depot Pond in Alternatives 4 or 4a. As an option to include Duck Island within the earthen dam, the dam could be tied into the west bank prior to Duck Island. This would keep Duck Island as an island and would require some other modifications, but it would not change those basic alternatives or significantly impact the projected cost. It is anticipated that regardless of which alternative is selected, refinement of the alternative and selection of various options will occur in the design process. This is due to the availability of more detailed field information, more design effort and input from stakeholders.

The people of Batavia have input on the selection of unique set of alternatives for the replacement the Batavia dam. All of the alternatives will provide the town with a valuable amenity that will become a legacy for many generations.